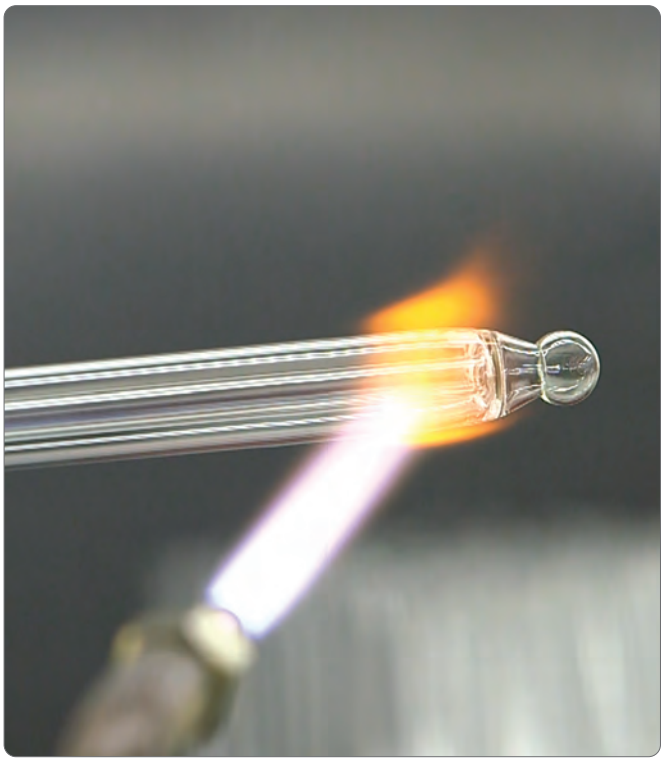
pH Electrodes

Designed and Manufactured by Hanna



At the Forefront of Electrode Technology

Hanna is the largest family-owned manufacturer of scientific analytical instrumentation, and a major European producer of electrodes. Hanna has helped propel the field of sensor technology with it's innovative methodology. The Hanna line of pH electrodes is produced in state of the art manufacturing facilities, and is available with glass or thermal plastic bodies.

In 1981, Hanna developed its own formulation for sensing glass with the help of the Experimental Institute for Glass in Murano Italy. From that point forward, the company has continued to offer these premium pH sensing glass electrodes that cannot be imitated. While other companies have reduced their offerings, Hanna has continued to expand their electrode line to support a multitude of specific applications. An extensive variety of cleaning and maintenance solutions are also available to keep electrodes at peak performance.

pH Electrode Manufacturing

Other electrode producers use the continuous fusion technique in crucibles with induction furnaces. In this practice, the glass is exposed to the fusion temperature for hours, where it is difficult to retain the quality of the product due to the evaporation of some of its components. Hanna uses glass blowing technology typical of the Murano masters, with sensitive glass sticks fused in controlled batches. Only this technique, which exposes the sensitive glass to the high fusion temperature for a matter of seconds, can guarantee the consistency and quality of the pH half-cell.

pH Theory and Measurement

The most common pH measurement system utilizes glass pH electrodes. The system consists of a pH sensor (whose voltage varies proportionately to the hydrogen ion activity of the solution), a reference electrode (which provides a stable and constant reference voltage), a conductive measurement solution, and a special meter to measure and display the pH.

The pH sensor incorporates a thin membrane of hydrogen-sensitive glass blown on the end of an inert glass tube. This tube is filled with a buffered electrolyte and an Ag/AgCl wire. This system is called a pH half-cell.

A complementary system produces a constant voltage; it also contains a Ag/AgCl wire and an electrolyte (often a KCl solution saturated with AgCl). A small "filter", often a porous ceramic component, connects this tube to the external sample. This system is called a reference half-cell.

The meter measures the voltage difference between the pH half-cell and the reference half cell in DC millivolts. The measurement is read by the meter and displayed in either mV or pH units. The mV response by a pH electrode follows the Nernst Equation:

$$E^{obs} = E^{c} + \ln(10)(RT / nF)(\log[a_{H^+}])$$

E^{obs} = Observed potential
E^{c} = Reference potential including other stable and fixed potentials
a_{H^+} = The hydrogen ion activity
T = Temperature in Kelvin (C° + 273.15)
n = Valence of the ion measured (1)
F = Faraday's constant (9.6485×10^4)
R = Gas constant (8.31432J / KMol)

From this equation one can see that if the temperature (T) changes, the term ln(10)RT / nF known as the slope factor, will change also. The table below illustrates the change in slope factor for changes in temperature.

Temperature (°C)	Slope Factor (mV/pH)
05	55.18
10	56.18
15	57.18
20	58.17
25	59.16
30	60.15
35	61.14

How Temperature Affects Solution pH

Samples change pH as a function of temperature due to changes in ion dissociation; as temperature increases, ion activity also increases. An example of this is pH buffers, whose well-characterized values are published on the buffer bottles. With very pure water, a change of ~1.3 pH is observed between 0 and 100°C. This example shows that even a neutral solution can have a large temperature coefficient. All samples have a temperature coefficient that is variable for actual samples. Changes in pH due to the sample temperature coefficient are not compensated for. There is, however, an exception to this; because buffers are well-characterized, they are compensated for during calibration on intelligent pH meters. The buffers will display a 25°C value during calibration but will change after the calibration to read their actual pH at the temperature of measurement.

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pH Measuring System

pH Electrode

The sensor half-cell of an electrochemical cell is typically composed of a special glass membrane that responds to a hydrogen ion concentration.

Reference Electrode

The half-cell of an electrochemical cell that supplies a stable voltage that is known, constant, and completely insensitive to the measurement solution. Changes in voltages generated from the pH sensor are measured versus this electrode's voltage.

High Input Impedance Meter

The measurement device that processes the voltage from the electrochemical cell and converts it into a meaningful measurement unit (pH). The measurement is done with virtually zero current flow to prevent polarization of the electrodes. Modern pH meters also may provide sensor diagnostics, automatic buffer recognition, calibration reminders and user prompts.

Chemical pH Buffers

Buffers are stable, well-characterized standards used for calibration. Two or more pH buffers that bracket the sample pH range are suggested for the most accurate results.

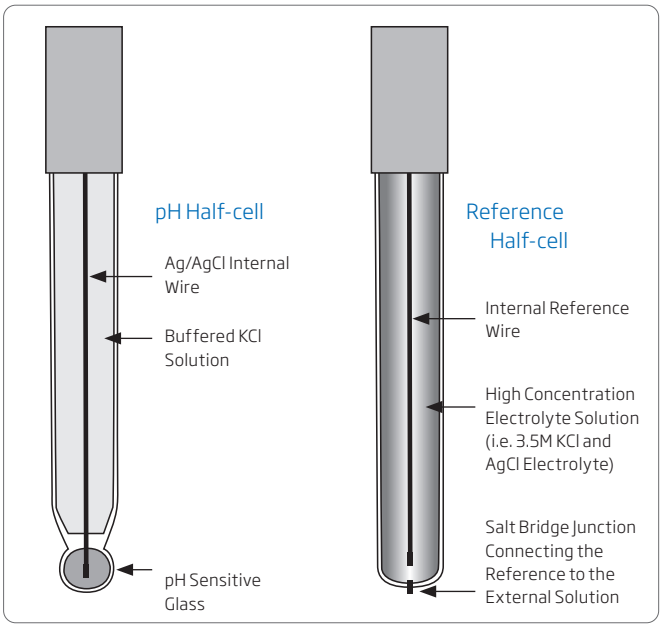
Thermometer or Temperature Probe

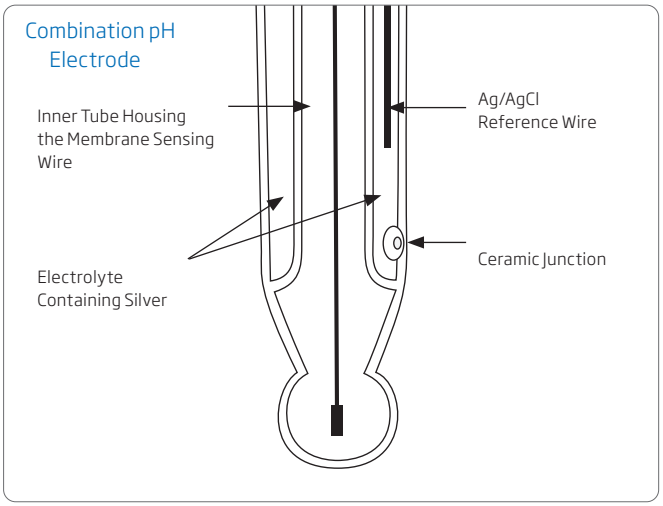
A temperature measurement is desired during calibration and measurement to make adjustments to the Nernst slope factor. An auxiliary or built-in temperature probe ensures both calibration and measurement are automatically temperature compensated, thus eliminating error.

Magnetic Stirrer

Used in a laboratory setting, a magnetic stirrer together with magnetic stir bars continually agitate the buffer and/or samples to keep them homogenous, eliminating temperature or sample gradients.

Electrode Design





Half-cells vs. Combination pH electrodes

Until the 1970s, it was a common practice to offer two half cells separately, a glass pH sensor and a reference electrode. Today it is more common to use a single combined electrode that has both sensing and reference components. Reference electrodes still enjoy use in other electrochemical techniques and their use is often preferred with ion selective electrodes (ISE) half-cells.

pH Electrodes

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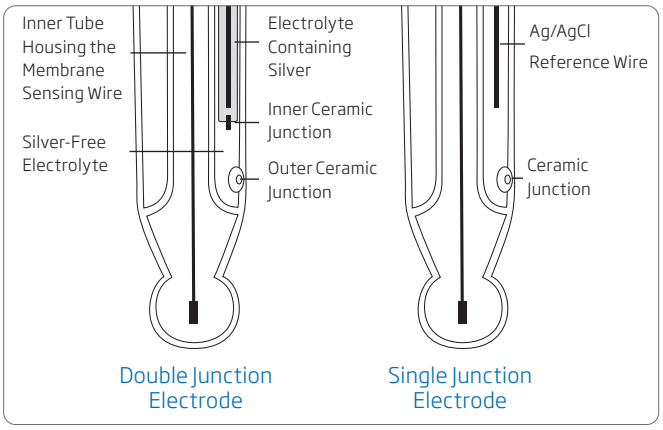
Single Junction vs. Double Junction

Conventional electrodes are normally single junction. As depicted by the figure below, these electrodes have only a single junction, which serves to put the reference electrode system in contact with the sample. Under adverse conditions, such as high pressure, high temperature, highly acidic or alkaline solutions etc., the positive flow of the electrolyte through the junction is often reversed resulting in the ingress of sample solution into the reference compartment. If this is left unchecked, the reference electrode can become contaminated, leading to complete electrode failure. Another potential problem with single junction electrodes is the clogging of the junction due to AgCl precipitation. AgCl is less soluble in the sample than the reference electrolyte solution. Therefore, when the electrolyte solution makes contact with the sample, some AgCl will precipitate on the external face of the junction. The result is drifty readings obtained from the sensor.

Hanna's double junction system, as the name implies, has two junctions, only one of which is in contact with the sample as shown in the figure below. Under adverse conditions, the same tendency of sample ingress is possible. However, as the reference electrode system is separated physically from the intermediate electrolyte area, the contamination of the electrode is minimized. The likelihood of clogging of the junction is also reduced with a double junction electrode since the outer reference cell uses a fill solution that is "silver-free." Since there is no silver present, no precipitate can form to clog the junction.

Single junction electrodes use a fill solution such as the HI7071 that contains 3.5M KCl + AgCl, while double junction electrodes typically use HI7082 that contains 3.5M KCl.

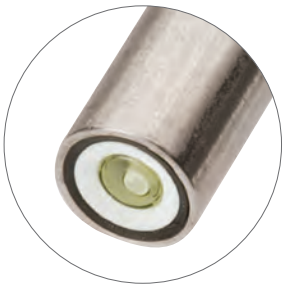


Types of Junctions:

Porous Ceramic

Normally used in electrodes with glass bodies because ceramic with the correct expansion coefficient is easily welded to glass. Ceramic is available with different porosities and diameters. It may also be referred to as a diaphragm.

Porous PTFE (Polytetrafluoroethylene)

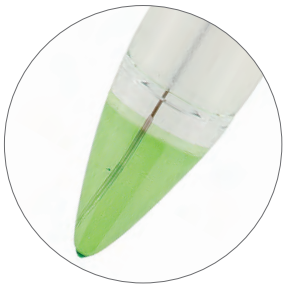


Porous PTFE is a hydrophobic material that is available with different porosities. Because of its chemical resistance, PTFE is widely used in industrial applications.

Fiber Wick

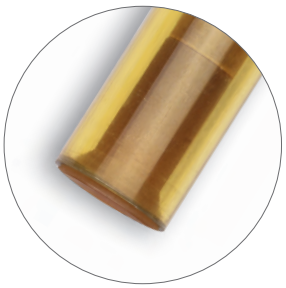
This type of junction is often used on plastic bodied electrodes with gel electrolytes.

Open Junction



This type of junction is often found in foodcare pH electrodes and is filled with a special gel which comes into direct contact with the solution to be measured. An advantage of an open junction is low contact resistance and low clogging potential.

Cone Style



This style junction is also renewable. As the sleeve or collar is moved, fresh fill solution cleans out the junction with fresh electrolyte. This has a higher flow rate than a ceramic type and is often specified for ISE measurements.

Other types of junctions include:

Capillary Junction

This type of junction can be made with smooth or frosted glass. The advantage of a capillary junction is a fast flow rate and an open channel. It is typically used with thickened electrolytes.

Open Platinum

This style junction is made by partially sealing fine Pt wires through the stem glass, creating a leakage path. These have high flow rates.

Fiberglass

This style junction is very similar to a fiber wick. The junction is typically renewable and may have a high flow rate depending on strand number in the bundle.

Four Different pH Sensitive Glass Formulations

Application driven design has influenced our offering of pH glass formulations. Hanna has selected the best glass compositions possible for each sensor to ensure the most accurate measurements in a given application. The characteristics of the sensitive glass used in the manufacture of pH electrodes are extremely important in determining how the electrode will respond. Characteristics of pH glass include workability (what shapes can be made with a certain glass composition), impedance of the glass (influenced by shape and thickness), pH range, alkaline error, acid error, hydrofluoric acid resistance and abrasion resistance.

Hanna utilizes four different types of pH sensitive glass to cover the vast number of applications. For instance, some electrodes with low impedance glass are particularly suited at performing measurements in solutions with low conductivity or cold solutions. As a general rule, the pH of glass impedance doubles for every 10°C (50°F) drop in temperature. Very high impedance results in a very noisy, erratic signal that is prone to errors in measurement. Hanna offers low temperature (LT) glass, a low impedance glass for these applications. At elevated temperatures, glass can dissolve readily, shortening the life and performance of the sensor. Hanna offers high temperature (HT) glass for these applications.

GP Glass

Hanna's general purpose (GP) hydrogen sensitive glass provides the best response over the entire pH range and can be used for a wide range of applications. Great results are obtained with a sphere geometry with a diameter of 9.5 mm (0.37"), achieving a system with 100 MΩ impedance. The GP glass is also used on smaller diameter spheres. As the diameter of the sphere is reduced, the system impedance increases. The response time then increases from the usual 2 seconds for the 9.5 mm (0.37") sphere to about 6 seconds with a 3 mm (0.12") sphere. The color of the GP glass is green.

LT Glass

Due to low impedance, LT glass is used on flat and conical shaped membranes, as well as sensors used at cold temperatures. If an electrode has very high impedance, the measurement response will be sluggish, and a voltage drop causing error can occur. At temperatures below -8°C (17°F) the internal buffer may freeze and expand, causing the mechanical destruction of the sensor. This glass has a more limited pH range, and is colored dark green.

HT Glass

Designed for extended use at elevated temperature, the impedance of HT glass has a temperature coefficient of about 14.3% per degree Celsius. HT sensitive glass has an impedance of 400 MΩ at approximately 25°C (77°F). At extremely high temperatures the impedance drops significantly; HT glass makes it possible to obtain accurate, high temperature pH measurements for extended periods of time at 90°C (194°F) and for several weeks at 100°C (212°F). At room temperature, the response time may increase so additional time for equilibration in buffers should be allowed. The color of HT glass is clear.

HF Glass

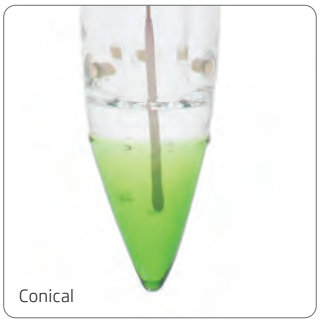
Hydrofluoric acid can dissolve glass rapidly. Hanna uses HF resistant glass for aggressive applications that have fluoride ions. Electrodes manufactured with this glass live ten times longer than electrodes made with standard pH glass formulations (from 10 days to 100 days). The alkaline error is very high for this glass, so it is not suited for pH measurements above pH 10. The recommended pH range with this glass is from 2 to 10 pH and for samples with less than 2 g/L fluoride.

Different Shaped Membranes (Tips)

The pH membranes used as the sensor on pH electrodes can be fabricated with different shaped membranes; spherical, conical, and flat tips are used in Hanna's products. For analysis of small samples, microelectrodes are also available.


Spherical

A **spherical tip** is recommended for general use in aqueous or liquid solutions and provides a wide surface of contact with the sample.


Conical

A **conical tip** is recommended for semi-solid products, emulsions, cheese, meat, and food in general.

A **flat tip** is recommended for direct surface measurement on skin, leather, paper, etc.


Flat

Body Material

Combination pH electrodes are often made entirely of glass. The bodies of these electrodes are lead free glass, which is not pH sensitive. All glass electrodes are ideal for routine laboratory work because they respond quickly to temperature changes, are easily cleaned, and are compatible with organic solvents. However, in the hands of some, glass can be very breakable.

The electrode body can be made less fragile by incorporating an outer body made from a thermoplastic. Hanna uses PEI resin, PVDF and PP as examples of materials utilized for outer body construction. Some industrial sensors utilize additional materials such as PVC and/or titanium, the space age metal. A titanium body increases immunity to electrostatic and magnetic fields and features strong corrosion resistance, even in seawater. Our titanium bodied electrodes' outer casing also serves as a matching pin.

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Matching Pin

A matching pin is a differential measurement technique used to eliminate ground loops and common mode perturbations for a measurement system. In a system without a matching pin, electrical currents in the sample can affect the reference half cell voltage that is connected via the liquid junction with the sample. In this case, the reference electrode picks up the electromagnetic fields and the measurement of the pH is altered. The matching pin isolates these current/magnetic fields from the reference electrode. Hanna manufactures a number of models with the matching pin design for safe precise pH measurements.

Types of Connectors

Most Hanna meters accept pH electrodes with one of the connectors listed below.

The BNC connector is the most versatile since it can be used with any meter that utilizes BNC, regardless of brand.

DIN, 3.5 mm, Screw, and T-type connections are generally proprietary to the meters they are supplied with. Screw and T-Type connectors attach directly to the meter.

Even though both Screw and T-type connectors attach directly to the meter, they can also be made interchangeable with other meters by using Hanna BNC extension cables.


DIN


Quick Connect DIN


BNC


BNC + PIN


T-Type


Screw


3.5 mm digital

Water Conductivity and pH Measurement

pH is the measurement of hydrogen ion activity. Ultrapure water is the perfect solvent and readily dissolves many things. The pH glass surface can actually become dehydrated if stored or used in deionized or distilled water as ions are leached from the sensing surface. pH electrodes require ions in a solution, preferably with a conductivity of or exceeding 200 µS/cm to function properly.

In the case of low conductivity samples that are below 200 µS/cm, we suggest the use of specific electrodes, such as the HI1053 which has LT glass suitable for low temperatures. This pH electrode has a triple ceramic junction that allows a higher flow rate of reference electrolyte to help provide electrical conductivity.

Alkaline Error

Alkaline error exists in high pH solutions when the hydrogen ions in the gel layer are partially or completely substituted with alkali ions; the resulting pH displayed is lower than it actually should be.

The difference between the theoretical and measured pH is called the alkaline error. Sodium ions are typically the ions that are responsible, but potassium and lithium ions can also contribute to this error. In earlier glass compositions, the alkaline error was seen to start at 9 pH. Newer glass formulations and ones especially formulated to minimize this error now exhibit an error starting at 12 or 13 pH.

To solve the problem of alkaline error, Hanna's high temperature (HT) glass minimizes alkali error in highly alkaline solutions. The tables below show the alkaline error that exists with Hanna glass types at ambient temperatures:

Alkaline Error with 0.1 M Sodium

pH	GP	HT	LT	HF
10.0				
10.5				0.06
11.0				0.15
11.5			0.05	0.22
12.0	0.01		0.18	0.30
12.5	0.11	0.05	0.28	
13.0	0.23	0.11	0.35	
13.5	0.35	0.16	0.45	
14.0	0.48	0.20	0.54	

Alkaline Error with 1.0 M Sodium

pH	GP	HT	LT	HF
10.0			0.01	0.25
10.5			0.14	0.25
11.0	0.02		0.30	0.48
11.5	0.11	0.01	0.46	0.71
12.0	0.21	0.06	0.62	
12.5	0.32	0.11	0.79	
13.0	0.43	0.15		
13.5	0.45	0.21		
14.0	0.65	0.27		

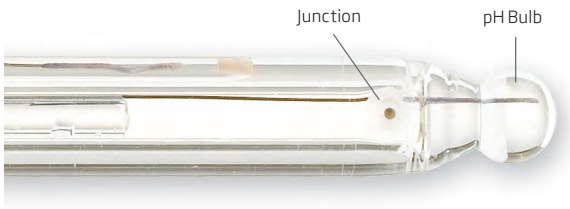
Calibration

pH Electrode Preparation Procedure

A clean, conditioned Hanna pH electrode will provide the best measurements possible. When using a new electrode, remove the protective bulb cap and inspect the electrode.

As water may have evaporated during shipping or storage, salt crystals may be found in and around the protective cap or on the pH bulb, this is normal .

Rinse off with water. During transport, air bubbles may have formed inside the glass bulb. Shake down the electrode as you would with a spirit filled thermometer. Condition the sensing tip; soak the pH bulb and junction in HI70300 storage solution for at least one hour or longer. If possible, an overnight soak is best. This will hydrate a dehydrated glass sensor and thoroughly wet a dried reference junction.



Rinse Electrode with Purified Water

Prior to placing the electrode in calibration solution, it should be thoroughly rinsed with clean, purified water to prevent any contamination to the pH buffer. The electrode should always be rinsed with purified water after placing it in any solution.

Use Fresh pH Buffer for Calibration

The calibration of the pH electrode is only as good as the buffer used. Once a bottle of buffer is open, it should be discarded after six months of use. To prevent cross-contamination, never pour buffer back into the bottle. If the same buffer is to be used for multiple calibrations, it is better to pour a small amount of buffer in a separate container that can be sealed. If using a separate container, the buffer should be changed frequently (i.e. daily, weekly).

It is important to note that pH buffers at higher values (i.e. pH 10.01) are less stable than lower values, this is due to atmospheric CO_2 diffusing into the buffer, forming carbonic acid. If the buffer is old, the actual value might be less than stated on the bottle, resulting in a low slope.

Open Reference Fill Cap on Refillable Electrodes

If using a refillable pH electrode, the fill cap should be removed prior to calibration and measurement. Removing the cap creates positive head pressure in the reference cell allowing for higher flow rate of electrolyte through the outer junction. A higher flow rate will result in a faster and more stable reading.

Submerse Electrode Past Junction

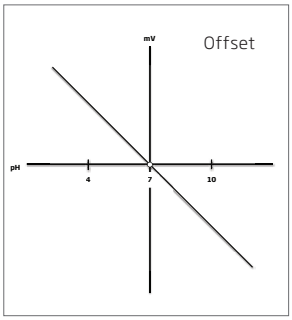
It is critical that the junction of the electrode be completely submersed in the pH buffer or sample. Failure to do so will result in erratic readings.

Use a Magnetic Stirrer

For benchtop meters, it is beneficial to use a magnetic stirrer. A magnetic stirrer will ensure that the pH buffer or sample is homogenous. The movement of the solution will also increase the response time of the electrode in the solution.

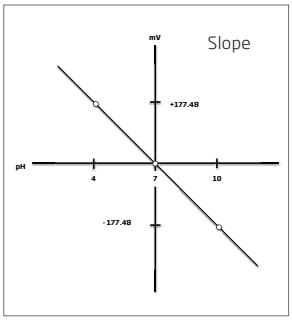
One-point Calibration

For one-point calibration it is important to calibrate the pH electrode in pH 7.0. This calibration determines the offset value. The mV value at pH 7.00 ideally should be 0.0.



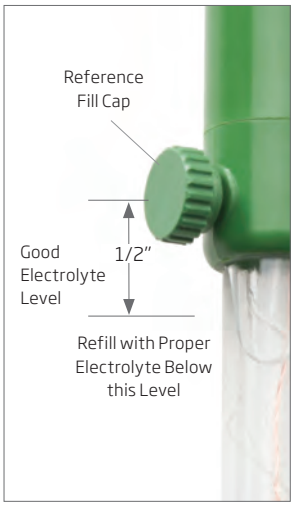
Multiple-point Calibration

For improved accuracy it is recommend to calibrate a minimum of two points. The second point determines the slope of the line. It is important to use buffers that bracket the expected value of the sample to be tested. For example, if the expected value is pH 8, the electrode should be calibrated using pH 7.01 and pH 10.01 buffer.



Electrode Fill Solutions

The electrolyte level in refillable electrodes should be checked before performing any calibration. If the level is low (1 cm or ½" below fill hole), refill with the proper electrolyte solution to ensure the optimum electrode performance. This simple maintenance step helps guarantee adequate head pressure to promote efficient and precise reading.



Always use the appropriate fill solution for your pH electrode. Typically single junction pH electrodes use the HI7071 electrolyte solution (3.5M KCl + AgCl) while double junction pH electrodes use HI7082 electrolyte solution (3.5M KCl).

pH Electrodes

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Maintenance and Storage

General Maintenance Tips

Periodically check the offset and slope characteristic of the pH electrode.

If your meter does not have GLP (Good Laboratory Practice) capability to display this information, see below on how to use the mV function of a pH meter to determine offset and slope characteristics. A probe should have an offset (pH 7.01) voltage of ± 30 mV. Values outside this range could indicate that an electrode needs to be cleaned or the reference fill solution is contaminated. A probe should have a slope greater than 85% (50 mV/pH @ 25°C). Many Hanna meters will alert the user if the offset exceeds ±8.0 mV or if the slope is less than 94%.

If it is not possible to check offset and slope of the electrode with your meter, it is recommended to change the pH electrode yearly to ensure that accurate readings are obtained.

How to calculate offset and slope

- Must have a pH meter that can be placed in mV mode
- Must use fresh buffers

The procedure below is based on calibration buffers at 25°C. At this temperature the theoretical 100% slope is 59.16 mV/pH change from pH 7.0. A pH electrode in calibration buffer at 50°C will generate 64 mV/pH, while at 0°C the response will be 54 mV/pH.

Step 1 Measure mV of pH 7.01 buffer and record value
Step 2 Measure mV value of pH 4.01 buffer and record value
Step 3 Calculate the absolute mV difference
(pH 4.01 value – pH 7.01 value)

Examples:

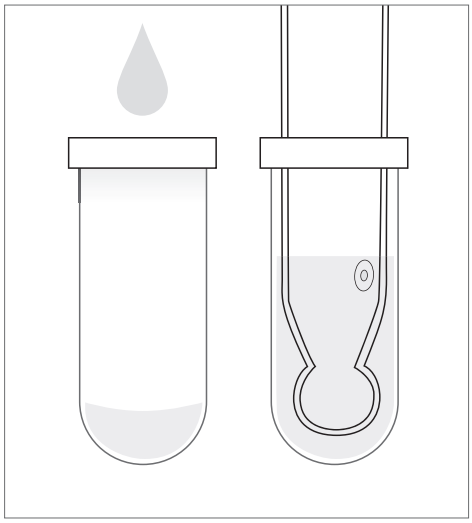
Electrode 1 pH 7.01 = -15 mV
pH 4.01 = +160 mV
Absolute mV difference is +160 mV – (-15 mV) = +175 mV

Electrode 2 pH 7.01 = +15 mV
pH 4.01 = +160 mV
Absolute mV difference is +160 mV – (-15 mV) = +145 mV

At 25°C pH 7.01 (offset) = ±30 mV.
The absolute mV difference should be 150 mV (85% slope) to 186 mV (105% slope).

Conclusion: Electrode 1 is working properly while electrode 2 has an unacceptable slope. Try cleaning and if possible replace fill solution. If slope is still low then replace the pH electrode.

Important note: A pH 7.01 mV value outside ±30 mV is an indicator of a build up/coating on the pH bulb. The electrode should be cleaned.



Electrode Storage Solutions

To minimize junction clogging and ensure fast response time, always keep the glass bulb and the junction of your pH electrode hydrated. For benchtop meters used in the lab pour a small amount of the HI70300 storage solution in a small beaker and lower the electrode into it making sure that the junction is covered. For portable meters, store the electrode with a few drops of HI70300 storage solution in the protective cap.

Storage solutions are designed to keep the pH electrode hydrated while minimizing growth on the electrode from bacteria and algae. Placing a probe in water will result in a growth on the electrode that might not be visible to the naked eye. This growth will affect the performance and accuracy. To minimize growth it is recommended to use pH 4 buffer if storage solution is not available. Solutions with lower pH values can inhibit growth. If pH 4 buffer is not available, it is advisable to use pH 7 buffer.

Never store a pH electrode in purified water as it will dehydrate the bulb. *The concentration of the fill solution is 3.5M KCl. The reference cell with this concentration generates a specific voltage. Placing a probe in purified water will have an osmotic effect causing water to move into the reference cell. There will also be a higher rate of diffusion of electrolyte from the reference cell into the water due to a concentration gradient. Both will result in a different reference electrolyte concentration, which will result in a change in the reference potential. If using a non-refillable probe in which the reference electrolyte cannot be changed, storage in purified water may result in premature failure and ultimately replacement of the electrode.*

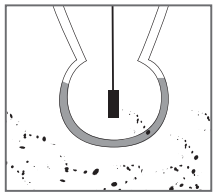
Inspect the electrode for any scratches or cracks on the bulb or stem.
If any are present, replace the electrode.

Electrode Cleaning

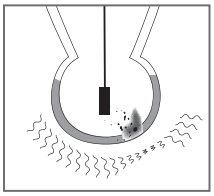
Cleaning Procedure

The most common cause for pH measurement inaccuracies is an unclean or improperly cleaned electrode. This is very important to note, because during calibration, the instrument assumes that the electrode is clean and that the standardization curve created during the calibration process will remain a valid reference until the next calibration. pH meters on the market today will allow an offset voltage of approximately ±60 mV. The deviation from 0 mV is not unusual but ideally should be no greater than ±30 mV. The calibration process compensates for the change in offset voltage.

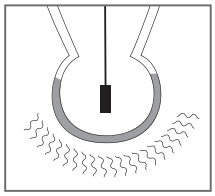
Calibrating a meter with a dirty electrode will result in inaccurate readings. If the mV offset continues to deviate with a properly cleaned electrode, it is a good indication that the electrode may need to be replaced.



In time, particles during routine measurement can contaminate the sensor tip. Mishandled and aged solutions can also be affected.



Your meter can still be calibrated even if the electrode sensor tip is not properly cleaned before calibration. If the contamination dissapates, the calibration is no longer valid and the readings are inaccurate.



A proper cleaning and fresh solution ensures the whole surface of the sensor tip is reading correctly, ensuring an accurate calibration.

General Cleaning

Soak in Hanna HI7061 General Cleaning Solution for approximately 30 minutes to dissolve mineral deposits and other general coatings.

Protein Coating

Soak in Hanna HI7073 Protein Cleaning Solution for 15 minutes to enzymatically dissolve deposits from protein sources.

Inorganic Soak

Soak in Hanna HI7074 Inorganic Cleaning Solution for 15 minutes. This cleaner is especially effective at removal of precipitates caused by reaction with the silver in the filling solution that may form on a ceramic junction.

Oil and Grease Rinse

Oil and grease removal require the correct chemicals to solubilize the coating, but are mild enough to leave the electrode unaffected. Use Hanna HI7077 Oil and Fat Cleaning Solution.

After performing any of the cleaning procedures, rinse the electrode thoroughly with purified water and then soak the electrode in HI70300 or HI80300 storage solution for at least 1 hour before taking measurements.

Troubleshooting

Drifting/Erratic Readings

Potential problems include:

Build up on glass electrode – Clean electrode

Clogged junction – Depending on the material clogging the electrode, use application specific cleaning solutions. It may be possible to dissolve in high purity water or place in an acid such as 0.1M HCl or 0.1M HNO_3 at elevated temperature (50°C) for about an hour to clear the clog.

If the junction is constantly clogging due to measuring in semi solids or viscous samples, use a pH electrode that has an open junction design or cloth junction.

Low conductivity solution – Use an electrode that has a high flow rate or add high purity KCl to sample to increase EC.

Electrode is not properly hydrated – Soak in storage solution for at least 1 hour, if not longer.

Frozen pH Reading

Broken electrode – Possible short between internal pH electrode and reference. pH meter displays the same value when placed in different buffers. The electrode should then be replaced.

Inaccurate Reading:

Improper calibration – Make sure that pH electrode was rinsed with purified water between buffers to prevent cross-contamination and the electrode is at thermal equilibrium with the buffer.

Check offset and slope of electrode. Offset mV value in pH 7.0 should be ±30 mV; if outside of this range, try cleaning the electrode. Slope (difference in mV from pH 7.0 to pH 4.0) must be greater than 150 mV (85%). If the slope is less than 85% then use fresh buffers, change fill solution, and clean electrode. If the slope cannot be increased to an acceptable value, replace electrode.

Important note: *A low slope can be due to a bad buffer. If calibrating to pH 7 and 10, it is possible that pH 10 buffer is no longer valid. pH 10 buffer is susceptible to diffusion of CO_2 from the air. When this happens, the pH 10 buffer will have a lower pH value and result in a low slope percentage value. Tracking the mV values of the buffer by writing the value on the bottle when opened is a way to have a reference point of a good buffer.*

85% slope is the absolute threshold of an acceptable slope percentage. There are industries that require a slope of 90% or higher.

pH Electrodes

Designed and Manufactured by Hanna

Calibrating and measuring at different temperatures–Either use a meter that has automatic temperature compensation or calibrate and measure at same temperature. Note that the buffer pH at various temperatures is noted on the bottle.

Measuring at high pH (>pH 10.0) introduces alkaline error– Use a pH electrode that has HT glass to minimize alkaline error.

Calibration with an electrode that was not clean–Any coating that comes off the electrode during use will alter the electrode characteristic, resulting in the calibration being no longer valid.

Electrical noise interference can interfere with obtaining an accurate pH measurement–Noise from rectifiers in plating baths, motors or pumps can interfere with the high impedance measuring circuit.

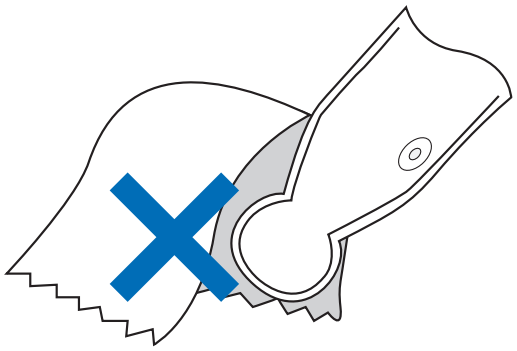
pH Electrode has a Short Life Span (< 6 months)

Elevated temperatures reduce the life span of pH electrodes. At room temperature (25°C) a pH electrode will typically last 1 to 2 years. A general rule is that for every 25°C increase the electrode life will decrease by ½. Temperature cycling has the most detrimental effect.

Operating Temperature	Average Lifespan
25°C	1 to 2 years
50°C	6 to 12 months
75°C	3 to 6 months
100°C	<1 month

If measuring samples at temperatures greater than 50 °C, use a pH electrode with high temperature (HT) glass such as the HI1043.

Storing a pH electrode in purified water will shorten the life span of pH electrode–If using a refillable pH electrode, replace fill solution; if using a gel-filled electrode, the electrode will have to be replaced. Store in storage solution.



Wiping a pH electrode with tissue will harm an electrode–It is important to blot a pH electrode. Wiping the electrode can produce a static charge on the sensor that will destabilize the measurement thus requiring additional time before stable measurements can be obtained.

Solutions with hydrofluoric acid will dissolve the glass at a pH less than pH 5. Use electrodes with HF resistant glass. The HI1143 will resist HF up to 2 g/L @ pH 2 and temperatures less than 60°C.

ORP Theory and Applications

ORP (Oxidation Reduction Potential)

Similar to the manner in which acidic or alkaline solutions are quantified by pH measurements, solutions can also be graded as oxidizing or reducing based on measurements of ORP (sometimes called "redox").

When an oxidizing and/or reducing agent is dissolved into an aqueous sample, they may react with materials present and produce a voltage, or electromotive force (EMF), that is related to the ratio of oxidized to reduce species in the sample. An electron exchange can develop between this solution and an inert metal sensor immersed in the solution, and the voltage can be measured (when compared to a reference electrode) with a pH/mV meter. This type of measurement is known as redox or ORP. The units of measurement are in mV. At a glance, an ORP electrode may look very similar to a pH electrode. Like a combination pH electrode, both the sensor and the reference are housed in a common body.

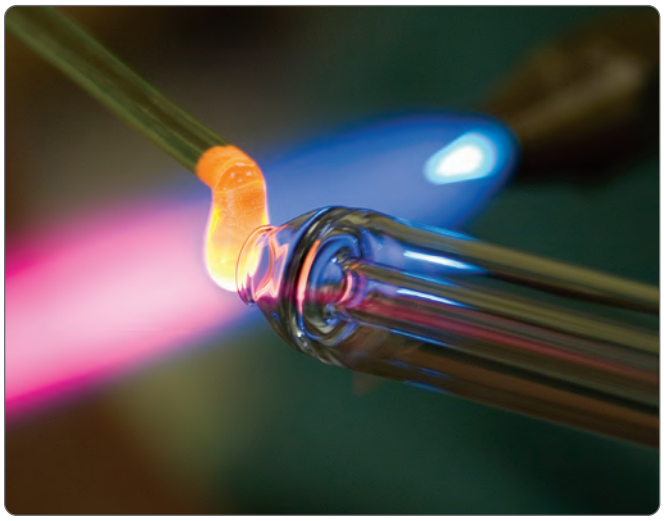
The scale of measurement may be positive (indicating oxidizing potential) or negative (indicating reducing). It should be noted that when zero mV is observed, it is really an oxidizing situation because the reference voltage (~200 mV for an Ag/AgCl with KCl electrolyte) is included in the observed mV value. In some cases the user may wish to offset the reading to remove the reference contribution. The mV is then said to be approaching the absolute mV scale that references a SHE (standard hydrogen electrode). This type of calibration is called relative mV calibration.

An ORP sensor must be chemically inert; it cannot be oxidized or reduced itself. It must also have the proper surface characteristics to promote rapid electron exchange, a property known as high exchange current density. Two noble metals have proven to work well for this purpose: pure platinum and pure gold are both used in the construction of ORP sensors.

The platinum sensor is often preferred because it is mechanically simpler and safer to produce. Platinum can be welded to glass and has the same thermal coefficient. Sensors made of gold cannot be welded to the glass and are often placed in plastic supports applied to the glass or plastic tube by means of tiny elastomeric bungs. The gold or platinum sensor signal is carried through the electrode body, and together with the reference signal is conducted to the measurement meter via a coaxial cable with BNC connector.

An ORP system does not have a high impedance source (like a pH bulb), but is a potentiometric device that produces a voltage. It also uses similar cables, connectors, and calibration solutions. For this reason, a high impedance electronic meter (pH) with many user friendly features are a benefit for this measurement also.

Because of the close relationship between pH and ORP, there is a scale that takes into account the ratio (mV) ORP/pH, the rH scale. The rH range varies from 0 to 42, where the extreme values represent the reducing effect of an atmosphere of pure hydrogen (rH=0) and to the oxidizing effect of an atmosphere of pure oxygen (rH=42), respectively.



The formula for obtaining the rH value is as follows:

$$rH = \frac{mV}{0.0992\,(273.15 + T_c)} - 2\,pH$$

In this equation, where T is the temperature (°C) of the sample, mV is the ORP (mV) reading, and pH is the pH value of the sample.

The rH scale is not used in the instruments available on the market. A direct mV reading from the electrode is preferred, within the ±2000 mV range, without compensation/correlation with the pH/temperature value.

ORP Applications

ORP measurements are based on the potential difference measured between the platinum or gold electrode and a reference electrode. The identical reference system utilized for the pH electrode (Ag/AgCl) is also used for redox measurements.

Redox electrodes are used to monitor many chemical processes particularly those involving reversible reactions. Common applications include the following:

Industrial Wastewater Treatment

The redox systems used in water treatment are the reduction of chromates and oxidation of cyanides. Waste hexavalent chromium is reduced to trivalent chromium by the addition of sodium bisulfite or sulphur dioxide. In the case of cyanide, chlorine or sodium hypochlorite is used to oxidize the cyanide, followed by the hydrolysis of cyanate to ammonia and carbon dioxide.

Water Sanitation

ORP measurements are being increasingly used as an effective measure of the sanitizing activity in pool, spa, and potable water. The kill time of E. coli bacteria in water depends on the ORP value. ORP is a reliable indicator of bacteriological water quality. Water having an ORP value equal to or higher than 650 mV are well within accepted sanitization levels for pool and spa waters.

Electrode Feature Guide: A Quick Glance

CAL Check™ System

When used in tandem with a Hanna CAL Check meter, our CAL Check equipped electrodes allow users to be informed if they have performed a proper calibration. In the event of a dirty or broken electrode or contaminated buffer solution, the system alerts the user to either check the electrode, replace the buffer solution, or both. The system also reminds users when the instrument should be recalibrated.

Smart Electrodes

With models that feature our SMART circuitry, an exclusive microchip embedded inside the electrode retains the calibration data and assigns an identity code to the host unit. As soon as the electrode is connected to a pH meter in the SMART series, it is recognized and its characteristics retrieved. The meter then uses the accessed calibration data as a reference for future measurements. Once each SMART electrode is calibrated, these electrodes can be used in succession without requiring new calibration. Hanna's SMART electrodes help eliminate errors and save time when working with more than one electrode.

Pre-amplified Electrodes

Pre-amplifiers are encapsulated in many of Hanna's pH electrodes. The pre-amplifier converts the high impedance signal from the pH glass to a low impedance signal; this allows the user to use long runs of sensor cable with ordinary connectors without noise or voltage drops that result in erroneous measurements.

Clogging Prevention System (CPS™)

Conventional pH electrodes use ceramic junctions that may clog quickly when used in biological samples, such as wine or must. When the junction is blocked, the entire electrode will not function properly. Electrodes that feature CPS technology utilize a ground glass/PE sleeve junction which controls a steady, predictable flow of fill solution, thus keeping the junction open. The hydrophobic property of PE sleeve repels wetness and coatings.

Sensor Check™ for edge® Meters

When used with Hanna's electrodes equipped with a matching pin, edge constantly checks the impedance of the pH measuring electrode to notify the user, in real-time, in the event of glass breakage. During calibration, Sensor Check also verifies the state of the junction.

Titanium Casings

Our electrodes that feature titanium bodies offer durability and shielding that is required in many industrial applications.

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Dome (D)	Plastic (P)
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Flat (F)	

Application	Recommended Electrodes	Tip Shape	Body Material	Single Reference	Double Reference	Cloth Junction	Ceramic Junction	Open Junction	Viscolene Electrolyte	Gel Electrolyte	KCl 3.5M Electrolyte	KCl 3.5M + AgCl Electrolyte	Refillable	SMART	Temperature Sensor	Amplifier	Pressure (Bar)	Page
Acids, Strong	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
Alkaline, Strong	HI2111B (half-cell) + HI5311	S	G		•		•				•						0.1	2.151, 2.152
Aquariums	HI1332B/P/D	S	P		•		•				•		•				0.1	2.140
Bases, Strong	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
Beer	FC2143	F	M	•		•				•					•	•	3	2.146
	HI1131B, HI1131P	S	G		•		•				•		•				0.1	2.135
	HI11313	S	G		•		•				•		•	•	•	•	0.1	2.135
	HI11310*	S	G		•		•				•		•	•	•	•	0.1	2.141
	HI11311*	S	G		•		•				•		•	•	•	•	0.1	2.141
Biotechnology (< 100 µl)	HI1083B, HI1083P	S	G	•				•	•								0.1	2.134
Boilers and Cooling Towers	HI729113	F	M		•		PTFE				Polymer				•	•	3	2.150
Cheese	FC200B/D	C	P	•				•		•							0.1	2.144
	FC2423, FC2423-1	C	M	•			•		•						•	•	0.1	2.147
	FC240B	C	M	•				•		•							0.1	2.145
	FC2023, FC2053	C	P		•			•	•					•	•	•	0.1	2.146
Chemicals	HI1332B/P/D	S	P		•		•				•		•				0.1	2.140
Conductivity, Low	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
	HI1053B, HI1053P	C	G		•		•				•		•				0.1	2.134
	HI10530*	C	G		•		•				•		•	•	•	•	0.1	2.141
	HI10533	C	G		•		•				•		•	•	•	•	0.1	2.134
Conductivity, High	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
Creams	FC210B	C	G		•			•	•								0.1	2.144
	FC220B	S	G	•			•					•	•				0.1	2.145
	FC911B	S	P		•		•				•		•			•	0.1	2.146
Dairy (general use)	HI2031B	C	G	•			•					•	•				0.1	2.137
	FC100B	S	P		•		•				•		•				0.1	2.144
	FC1013	S	P		•		•				•		•		•	•	0.1	2.144
Emulsions	HI1053B, HI1053P	C	G		•		•				•		•				0.1	2.134
	HI10530*	C	G		•		•				•		•	•	•	•	0.1	2.141
	HI10533	C	G		•		•				•		•	•	•	•	0.1	2.134
	HI1612D	C	G	•			•					•	•		•	•	0.1	2.139
	HI1413B	F	G	•				•	•								0.1	2.148
	HI14143	F	G	•				•	•						•	•	0.1	2.148
Fats and Creams	HI1053B, HI1053P	C	G		•		•				•		•				0.1	2.134
	HI10530*	C	G		•		•				•		•	•	•	•	0.1	2.141
	HI10533	C	G		•		•				•		•	•	•	•	0.1	2.134
Flasks	HI1331B	S	G	•			•					•	•				0.1	2.136
Fluoride, Samples with	HI1143B	S	G		•		•				•		•				0.1	2.136
Food Industry (General Use)	FC100B	S	P		•		•				•		•				0.1	2.144
	FC911B	S	P		•		•				•		•			•	0.1	2.146
Food, Semi-solid	FC2023, FC2053	C	P		•			•	•					•	•	•	0.1	2.146
	FC200B/D	C	P	•				•		•							0.1	2.144

*edge® specific electrode

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Application	Recommended Electrodes	Tip Shape	Body Material	Single Reference	Double Reference	Cloth Junction	Ceramic Junction	Open Junction	Viscolene Electrolyte	Gel Electrolyte	KCl 3.5M Electrolyte	KCl 3.5M + AgCl Electrolyte	Refillable	SMART	Temperature Sensor	Amplifier	Pressure (Bar)	Page
Fruits	FC200B/D	C	P	•				•		•							0.1	2.144
	FC2023, FC2053	C	P		•			•	•					•	•	•	0.1	2.146
Fruit Juices, Organic	FC220B	S	G	•			•					•	•				0.1	2.145
	FC911B	S	P		•		•				•		•			•	0.1	2.146
Frozen, Semi	FC230B	C	P	•				•	•								0.1	2.145
Ham and Sausages	FC200B/D	C	P	•				•		•							0.1	2.144
	FC2023, FC2053	C	P		•			•	•					•	•	•	0.1	2.146
	FC230B	C	P	•				•	•								0.1	2.145
Humidity, High	FC911B	S	P		•		•				•		•			•	0.1	2.146
Hydrocarbons	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
Laboratory (General Use)	HI1131B, HI1131P	S	G		•		•				•		•				0.1	2.135
	HI11313	S	G		•		•				•		•	•	•	•	0.1	2.135
	HI1230B	S	P		•		•			•							2	2.136
	HI12303	S	P		•		•			•				•	•	•	2	2.136
	HI1217D, HI1291D	S	P	•			•			•					•	•	2	2.138
	HI1610D	S	G	•			•					•	•		•	•	0.1	2.139
	HI11310*	S	G		•		•				•		•	•	•	•	0.1	2.141
	HI11311*	S	G		•		•				•		•	•	•	•	0.1	2.141
	HI12300*	S	P		•		•			•				•	•	•	2	2.143
	HI12301*	S	P		•		•			•				•	•	•	2	2.143
	HI1110B	S	G	•			•			•							0.1	2.136
	HI11103	S	G	•			•			•				•	•	•	0.1	2.136
Leather	HI1413B	F	G	•				•	•								0.1	2.148
	HI14143	F	G	•				•	•						•	•	0.1	2.148
Meats	FC230B	C	P	•				•	•								0.1	2.145
	FC400B	C	P		•			•	•								0.1	2.145
	FC2323	C	P	•				•	•						•	•	0.1	2.147
	FC2023, FC2053	C	P		•			•	•					•	•	•	0.1	2.146
	FC2320*	C	P		•			•	•					•	•	•	0.1	2.142
Milk	FC100B	S	P		•		•				•		•				0.1	2.144
	FC1013	S	P		•		•				•		•		•	•	0.1	2.144
	FC260B (half-cell)	S	G															2.151
Monitoring, Continuous	HI1135B	S	G		•		•				•		•				3	2.135
	HI1611D	S	G	•			•			•					•	•	2	2.139
Must in Winemaking	HI1048B/P, HI1048B/50	D	G		•			•			•		•				0.1	2.146
	FC10483	D	G		•			•			•		•		•	•	0.1	2.146
	HI10480*	D	G		•			•			•		•	•	•	•	0.1	2.142
NMR Tubes	HI1093B, HI1093P	S	G	•				•	•								0.1	2.135
Paints	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
Paper	HI1413B	F	G	•				•	•								0.1	2.148
	HI14143	F	G	•				•	•						•	•	0.1	2.148
Photographic Chemicals	HI1230B	S	P		•		•			•							2	2.136
	HI12303	S	P		•		•			•				•	•	•	2	2.136
Plating Baths	HI629113	F	M		•		PTFE			Polymer					•	•	3	2.150
Quality Control	HI1332B/P/D	S	P		•		•				•		•				0.1	2.140
	FC240B	C	M	•				•		•							0.1	2.145

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Sauces	FC220B	S	G	•			•					•	•				0.1	2.145
	FC911B	S	P		•		•				•		•				0.1	2.146
Seawater	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
Semi-solid Products	HI1053B, HI1053P	C	G		•		•				•		•				0.1	2.134
	HI10530*	C	G		•		•				•		•	•	•	•	0.1	2.141
	HI10533	C	G		•		•				•		•	•	•	•	0.1	2.134
	HI1612D	C	G	•			•					•	•		•	•	0.1	2.139
	FC200B/D	C	P	•				•	•								0.1	2.144
	HI2031B	C	G	•			•					•	•				0.1	2.137
Skin, Scalp	HI1413B	F	G	•				•	•								0.1	2.148
	HI14143/50	F	G	•				•	•						•	•	0.1	2.148
Soil, Direct	HI12923	C	G	•			•					•	•		•	•	0.1	2.148
	HI12943**	C	G	•			•					•	•		•	•	0.1	2.149
Soil Solution	HI1053B, HI1053P	C	G		•		•				•		•				0.1	2.134
	HI10530*	C	G		•		•				•		•	•	•		0.1	2.141
	HI10533	C	G		•		•				•		•	•	•	•	0.1	2.134
	HI1230B	S	P		•		•			•							2	2.136
	HI12923	C	G	•			•					•	•		•	•	0.1	2.148
	HI12943**	C	G	•			•					•	•		•	•	0.1	2.149
Solvents	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
Surface Measurements	HI1413B	F	G	•				•	•								0.1	2.148
	HI14143	F	G	•				•	•						•	•	0.1	2.148
	HI14140*	F	G	•				•	•					•	•	•	0.1	2.142
Swimming Pools	HI12973	C	M	•		•				•					•	•	3	2.149
Titrations, Non Aqueous	HI1049B	D	G		•			•			•		•				0.1	2.148
	HI1151B	S	G		•		•					•	•				0.1	2.135
Tris Buffer	HI1043B, HI1043P	S	G		•		•				•		•				0.1	2.134
	HI10430*	S	G		•		•				•		•	•	•	•	0.1	2.141
	HI1144	S	G	•			•				•		•				0.1	2.137
	HI1343B	S	P	•			•				•		•				0.1	2.137
Vials and Test Tubes	HI1330B, HI1330P	S	G	•			•					•	•				0.1	2.137
Wastewater	HI12963	S	M	•		•				•					•	•	3	2.149
	HI12973	C	M	•		•				•					•	•	3	2.149
Water, High Purity	HI1053B, HI1053P	C	G		•		•				•		•				0.1	2.134
	HI10530*	C	G		•		•				•		•	•	•		0.1	2.141
	HI10533	C	G		•		•				•		•	•	•	•	0.1	2.134
Water, Municipal	HI12973	C	M	•		•				•					•	•	3	2.149
Water, Potable	HI1053B, HI1053P	C	G		•		•				•		•				0.1	2.134
	HI10530*	C	G		•		•				•		•	•	•		0.1	2.141
	HI10533	C	G		•		•				•		•	•	•	•	0.1	2.134
	FC2153	S	G	•			•					•	•		•	•	0.1	2.149
Water Treatment	HI12973	C	M	•		•				•					•	•	3	2.149
Yogurt	FC200B/D	C	P	•				•	•								0.1	2.144
	FC210B	C	G		•			•	•								0.1	2.144
	FC2133	C	G		•			•	•						•	•	0.1	2.147
	FC2023, FC2053	C	P		•			•	•					•	•	•	0.1	2.146
	FC2100*	C	G		•			•	•					•	•	•	0.1	2.142
	FC2020*	C	P		•			•	•					•	•	•	0.1	2.142

*edge® specific electrode; **HI9814 GroLine® portable meter specific electrode

Unsure about which electrode to choose? Give your local Hanna office a call for assistance.

ORP Electrode Application Guides

Abbreviation Guide

Platinum (Pt) Gold (Au) Glass (G) Plastic (P)

Application	Recommended Electrodes	Sensor	Body Material	Single Reference	Double Reference	Cloth Junction	Ceramic Junction	Open Junction	Gel Electrolyte	KCl 3.5M Electrolyte	KCl 3.5M + AgCl Electrolyte	Refillable	SMART	Temperature Sensor	Amplifier	Pressure (Bar)	Page
Field	HI36203	Pt	P	•			•		•					•	•	2	2.140
Laboratory (General Use)	HI3131B	Pt	G	•			•				•	•				0.1	2.138
	HI3618D, HI36183	Pt	G	•			•				•	•		•	•	0.1	2.138
	HI36180*	Pt	G		•		•				•	•	•	•	•	0.1	2.143
	HI36200*	Pt	P	•			•		•				•	•	•	2	2.143
Must in Winemaking	HI3149B	Pt	G		•			•		•		•				0.1	2.138
Oxidants	HI4430B	Au	P	•			•		•							2	2.140
Ozone	HI4430B	Au	P	•			•		•							2	2.140
Quality Control	HI3230B	Pt	P	•			•		•							2	2.140
Titrations, ORP	HI3131B	Pt	G	•			•				•	•				0.1	2.138
Water, Municipal	HI3230B	Pt	P	•			•		•							2	2.140
Must in Winemaking	HI3148B	Pt	G		•			•		•		•				0.1	2.146

*edge® specific electrode

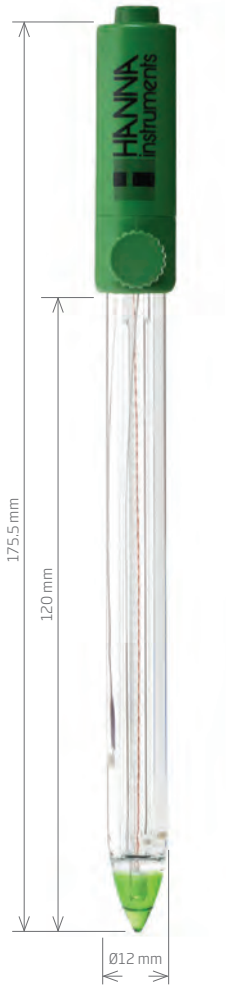
Half-Cell and Reference Electrode Application Guides

Abbreviation Guide

Spheric (S) Cylindric (C) Platinum (Pt) Gold (Au) Glass (G) Plastic (P)

Application	Recommended Electrodes	pH Half Cell	ORP Half Cell	Reference	Tip Shape	Body Material	Single Reference	Double Reference	PE Sleeve Junction	Ceramic Junction	KCl 3.5M Electrolyte	Pressure (Bar)	Page
Laboratory (General Use)	HI2111B	•			S	G							2.151
	HI2112B	•			S	P							2.151
	HI3133B		•		Pt	G							2.151
	HI5412			•		G	•			•	•	0.1	2.152
	HI5311			•		G		•		•	•	0.1	2.152
Milk	FC260B	•			S	G							2.151
Remote Filling	HI5314			•		G		•		•	•	3	2.152
	HI5414			•		G	•			•	•	3	2.152
Strong Alkaline Solutions	HI2111B	•			S	G							2.151
Suspended Solids	HI5413			•		G	•		•		•	0.1	2.153
	HI5312			•		G		•	•		•	0.1	2.153
	HI5313			•		P	•			•		0.1	2.153
Titration, Argentometric	HI5110B		•		C	G							2.151
Titrations, General	HI5412			•		G	•			•	•	0.1	2.152
	HI5311			•		G		•		•	•	0.1	2.152
	HI5312			•		G		•	•		•	0.1	2.153
	HI5313			•		P	•			•		0.1	2.153
Titration, Potentiometric	HI3133B		•		Pt	G							2.151

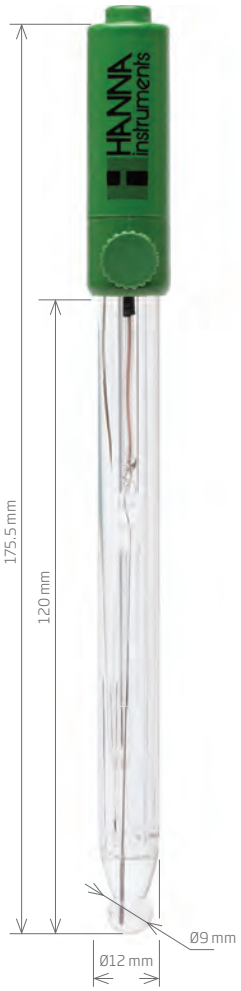
Combination Electrodes

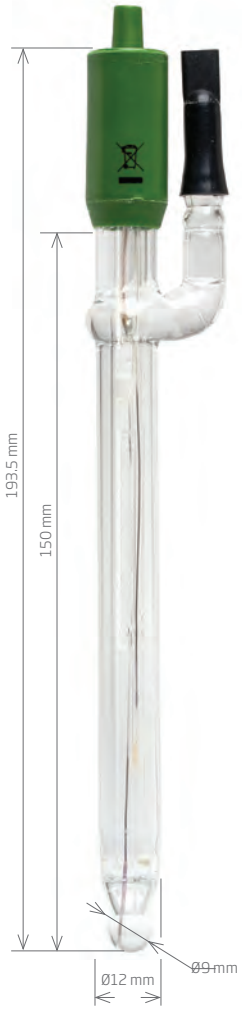


Code	HI1043[ ]	HI1053[ ]	HI10533	HI1083[ ]
Description	refillable, combination pH electrode w/ double junction	refillable, combination pH electrode w/ conical tip	refillable, combination pH electrode w/ conical tip	combination pH electrode w/micro bulb for small samples
Reference	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl
Junction / Flow Rate	ceramic, double / 30-40 µL/h	ceramic, triple / 40-50 µL/h	ceramic, triple / 40-50 µL/h	open
Electrolyte	KCl 3.5M	KCl 3.5M	KCl 3.5M	viscolene
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 14	pH: 0 to 12	pH: 0 to 12	pH: 0 to 13
Recommended Operating Temp.	0 to 100°C (32 to 212°F)	-5 to 70°C (23 to 158°F)	-5 to 70°C (23 to 158°F)	0 to 50°C (32 to 122°F)
Glass Type	HT (high temperature)	LT (low temperature)	LT (low temperature)	GP (general purpose)
Tip /Shape	spheric (dia: 9.5 mm)	conic (12 x 12 mm)	conic (12 x 12 mm)	spheric (dia: 3 mm)
Temperature Sensor	no	no	yes	no
Amplifier	no	no	yes	no
Body Material	glass – HT	glass – LT	glass – LT	glass – GP
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	hydrocarbons, paints, solvents, sea water, strong acids and bases, high conductivity samples, tris buffer	fats and creams, high purity water, soil samples, potable water, semi-solid products, low conductivity solutions, emulsions	fats and creams, high purity water, soil samples, potable water, semi-solid products, low conductivity solutions, emulsions	biotechnology, samples < 100 µL
Connection	**HI1043B** BNC **HI1043P** BNC + pin*	**HI1053B** BNC **HI1053P** BNC + pin*	**HI10533** Quick Connect DIN	**HI1083B** BNC **HI1083P** BNC + pin*
	* For pH meters with CAL Check™ system	* For pH meters with CAL Check system		* For pH meters with CAL Check system

Unsure about which electrode to choose? Give your local Hanna office a call for assistance.

Combination Electrodes





Code	HI1093B	HI1131[ ]	HI1151B	HI1135B
Description	combination pH electrode w/ extended length and micro bulb	refillable, combination pH electrode	refillable, combination pH electrode	refillable, combination pH electrode w/ side arm construction and fast flow rate
Reference	single, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl
Junction / Flow Rate	open	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, double / 30-40 µL/h
Electrolyte	viscolene	KCl 3.5M	–	KCl 3.5M
Max Pressure	0.1 bar	0.1 bar	0.1 bar	3 bar with back pressure
Range	pH: 0 to 14	pH: 0 to 14	pH: 0 to 13	pH: 0 to 14
Recommended Operating Temp.	0 to 50°C (32 to 122°F)	0 to 100°C (32 to 212°F)	0 to 100°C (32 to 212°F)	0 to 100°C (32 to 212°F)
Glass Type	GP (general purpose)	HT (high temperature)	HT (high temperature)	HT (high temperature)
Tip /Shape	spheric (dia: 3 mm)	spheric (dia: 9.5 mm)	spheric (dia: 9.5 mm)	spheric (dia: 9.5 mm)
Temperature Sensor	no	DIN model only	no	no
Amplifier	no	DIN model only	no	no
Body Material	glass – GP	glass	glass	glass
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	NMR tubes	laboratory general purpose, beer	non-aqueous titration	continuous monitoring with remote filling
Connection	**HI1093B** BNC **HI1093P** BNC + pin*	**HI1131B** BNC **HI1131P** BNC + pin* **HI11313** Quick Connect DIN	**HI1151B** BNC	**HI1135B** BNC

* For pH meters with CAL Check™ system

* For pH meters with CAL Check™ system

Combination Electrodes

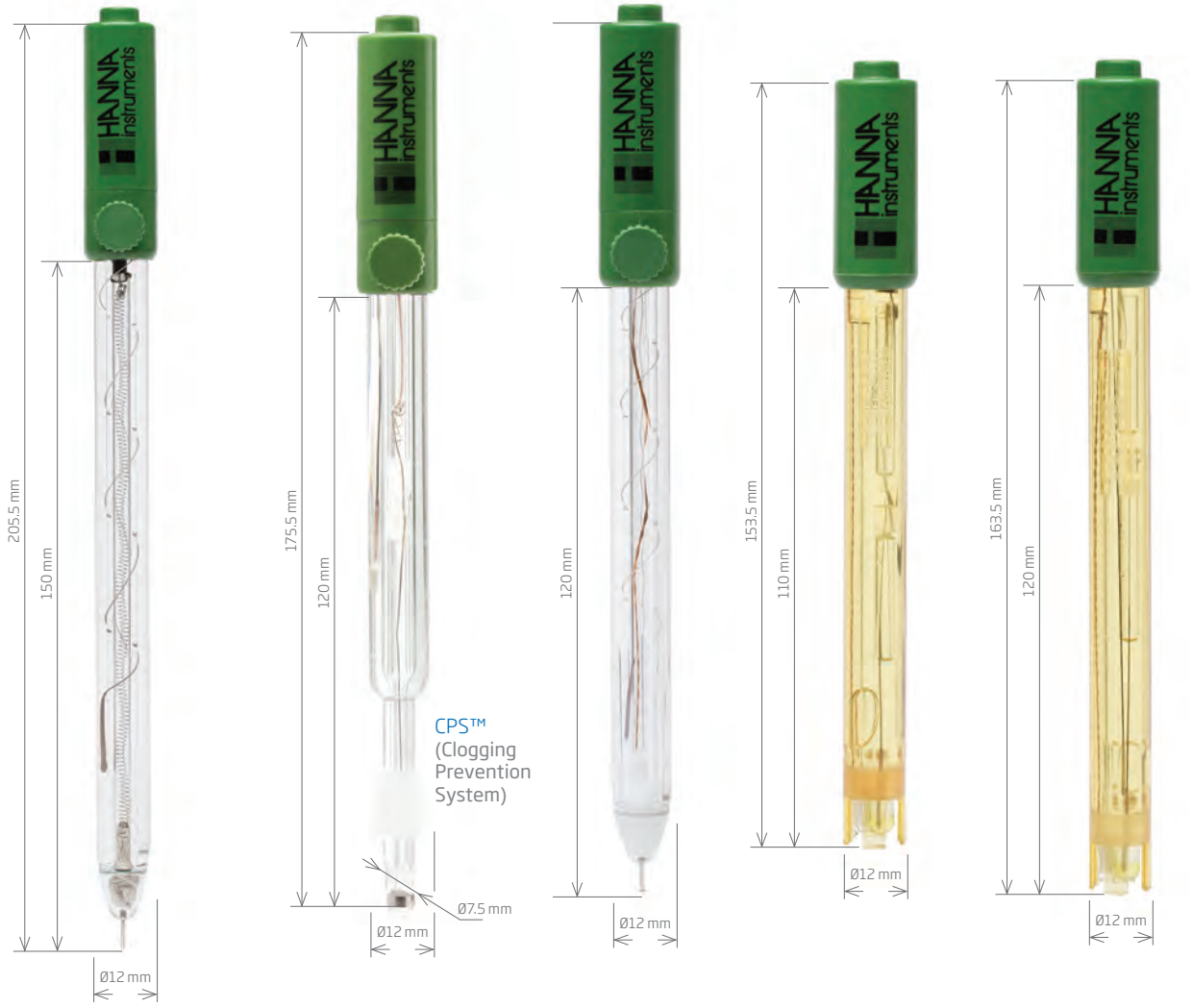
Code	HI1143B	HI1110[ ]	HI1331B	HI1230[ ]
Description	refillable, combination pH electrode for fluoride applications	combination pH electrode	combination pH electrode	combination pH electrode
Reference	double, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl	double, Ag/AgCl
Junction / Flow Rate	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h
Electrolyte	KCl 3.5M	gel	KCl 3.5M + AgCl	gel
Max Pressure	0.1 bar	0.1 bar	0.1 bar	2 bar
Range	pH: 0 to 10	pH: 0 to 13	pH: 0 to 13	pH: 0 to 12
Recommended Operating Temp.	-5 to 60°C (23 to 140°F) – HF	0 to 80°C (32 to 176°F) – GP	0 to 70°C (32 to 158°F) – GP	-5 to 70°C (23 to 158°F) – LT
Glass Type	HF (hydrofluoric acid resistant)	GP (general purpose)	GP (general purpose)	LT (low temperature)
Tip /Shape	spheric (dia: 9.5 mm)	spheric (dia: 9.5 mm)	spheric (dia: 7.5 mm)	spheric (dia: 7.5 mm)
Temperature Sensor	no	DIN model only	no	DIN model only
Amplifier	no	DIN model only	no	DIN model only
Body Material	glass	glass	glass	PEI
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	samples with fluoride (max 2 g/L @ pH 2 and temperature < 60°C)	general purpose	specific for flasks	field applications, soil solution, photographic chemicals, laboratory (general use)
Connection	**HI1143B** BNC	**HI1110B** BNC **HI11103** Quick Connect DIN	**HI1331B** BNC	**HI1230B** BNC **HI12303** Quick Connect DIN

Combination Electrodes

Code	HI1144B	HI1330[ ]	HI1343B	HI2031B
Description	refillable, combination pH electrode with calomel references	refillable, combination pH electrode	combination pH electrode	refillable, conical tip combination pH electrode
Reference	single, Hg/Hg_2Cl_2	single, Ag/AgCl	single, Hg/Hg_2Cl_2	single, Ag/AgCl
Junction / Flow Rate	ceramic / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h
Electrolyte	KCl 3.5M	KCl 3.5M + AgCl	KCl 3.5M	KCl 3.5M + AgCl
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 14	pH: 0 to 12	pH: 0 to 14	pH: 0 to 12
Recommended Operating Temp.	0 to 60°C (32 to 140°F) – HT	-5 to 70°C (23 to 158°F) - LT	0 to 60°C (32 to 140°F) - HT	-5 to 70°C (23 to 158°F) - LT
Glass Type	HT (high temperature)	LT (low temperature)	HT (high temperature)	LT (low temperature)
Tip /Shape	spheric (dia: 9.5 mm)	spheric (dia: 5 mm)	spheric (dia: 7.5 mm)	conic (6 x 10 mm)
Temperature Sensor	no	no	no	no
Amplifier	no	no	no	no
Body Material	glass	glass	PEI	glass
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	tris buffer	specific for vials and test tubes	specific for Tris buffer	dairy and semi-solid products
Connection	**HI1144B** BNC	**HI1330B** BNC **HI1330P** BNC + pin*	**HI1343B** BNC	**HI2031B** BNC

* For pH meters with CAL Check™ system

Special pH and ORP Electrodes



Code	HI3131B	HI3149B	HI3618D/HI36183	HI1217D	HI1291D
Description	refillable combination ORP electrode	ORP electrode	ORP combination electrode	pH electrode	pH electrode
Reference	single, Ag/AgCl	double, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl
Junction / Flow Rate	ceramic, single / 15-20 µL/h	CPS™	ceramic, single / 15-20 µL/h	ceramic, single	ceramic, single
Electrolyte	KCl 3.5M + AgCl	KCl 3.5M	KCl 3.5M + AgCl	gel	gel
Max Pressure	0.1 bar	0.1 bar	0.1 bar	2 bar	2 bar
Range	ORP: ±2000 mV	ORP: ±2000 mV	ORP: ±2000 mV	pH: 0 to 13	pH: 0 to 12
Recommended Operating Temp.	-5 to 70°C (23 to 158°F)	-5 to 60°C (23 to 140°F)	-5 to 70°C (23 to 158°F)	0 to 70°C (32 to 158°F)	0 to 70°C (32 to 158°F)
Glass Type	–	–	–	GP (general purpose)	GP (general purpose)
Tip /Shape	platinum pin	platinum ring	platinum pin	spheric (dia: 5.0 mm)	spheric (dia: 5.0 mm)
Temperature Sensor	no	no	yes	yes	yes
Amplifier	no	no	yes	yes	yes
Body Material	glass	glass	glass	PEI	PEI
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	5-pole; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	laboratory general use, ORP titrations	non-aqueous titrations	laboratory	general purpose	general purpose, education, laboratory
Connection	**HI3131B** BNC	**HI3149B** BNC	**HI36183** Quick Connect DIN **HI3618D** DIN**	**HI1217D** DIN**	**HI1291D** DIN**

** Recommended for use with HI8314 pH meter

** Recommended for use with HI8314 pH meter

** Recommended for use with HI207 and HI208 pH meters

pH Electrodes with Temperature Sensor

Code	HI1610D	HI1611D	HI1612D
Description	pH electrode	pH electrode	pH electrode
Reference	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl
Junction / Flow Rate	ceramic, single / 15-20 µL/h	ceramic, single	ceramic, triple / 40-50 µL/h
Electrolyte	KCl 3.5M + AgCl	gel	KCl 3.5M + AgCl
Max Pressure	0.1 bar	2 bar	0.1 bar
Range	pH: 0 to 13	pH: 0 to 14	pH: 0 to 12
Recommended Operating Temp.	0 to 70°C (32 to 158°F)	0 to 70°C (32 to 158°F)	-5 to 70°C (23 to 158°F)
Glass Type	GP (general purpose)	HT (high temperature)	LT (low temperature)
Tip /Shape	spheric (dia: 9.5 mm)	spheric (dia: 9.5 mm)	conic (12 x 12 mm)
Temperature Sensor	yes	yes	yes
Amplifier	yes	yes	yes
Body Material	glass	glass	glass
Cable	5-pole; 1 m (3.3')	5-pole; 1 m (3.3')	5-pole; 1 m (3.3')
Recommended Use	laboratory general use	continuous monitoring	emulsions, semi-solid samples
Connection	**HI1610D** DIN*	**HI1611D** DIN*	**HI1612D** DIN*

* Recommended for use with HI8314 pH meter

* Recommended for use with HI8314 pH meter

* Recommended for use with HI8314 pH meter

Tips for the Most Accurate Measurements

Keep Electrode Hydrated

Ideally, pH electrodes should be kept in a storage solution when not in use. Placing the electrode in a small glass filled with storage solution is suitable. An option for pocket meters is to place a small piece of sponge into the meter's cap and pour storage solution into the cap to wet the sponge. Pouring off any excess solution beforehand, the cap can then be placed on the meter.

If a storage solution is not available the next best option is to use pH 4.01 buffer (pH 7.01 is also suitable to a lesser extent).

Clean Electrodes Before Use

Clean the junction of your electrodes once a day or at least once a week to prevent junction clogging and to maintain accuracy. Immerse the electrode in the proper cleaning solution for at least 15 to 20 minutes. Hanna offers a wide range of cleaning solutions for general purpose and specific applications.

Replace Electrodes Once a Year

If your electrode takes too long to stabilize a reading, or readings fluctuate wildly, it is most likely time to replace the electrode. The typical life span of any pH electrode is from 6 months to 1.5 years.

Additional Tips

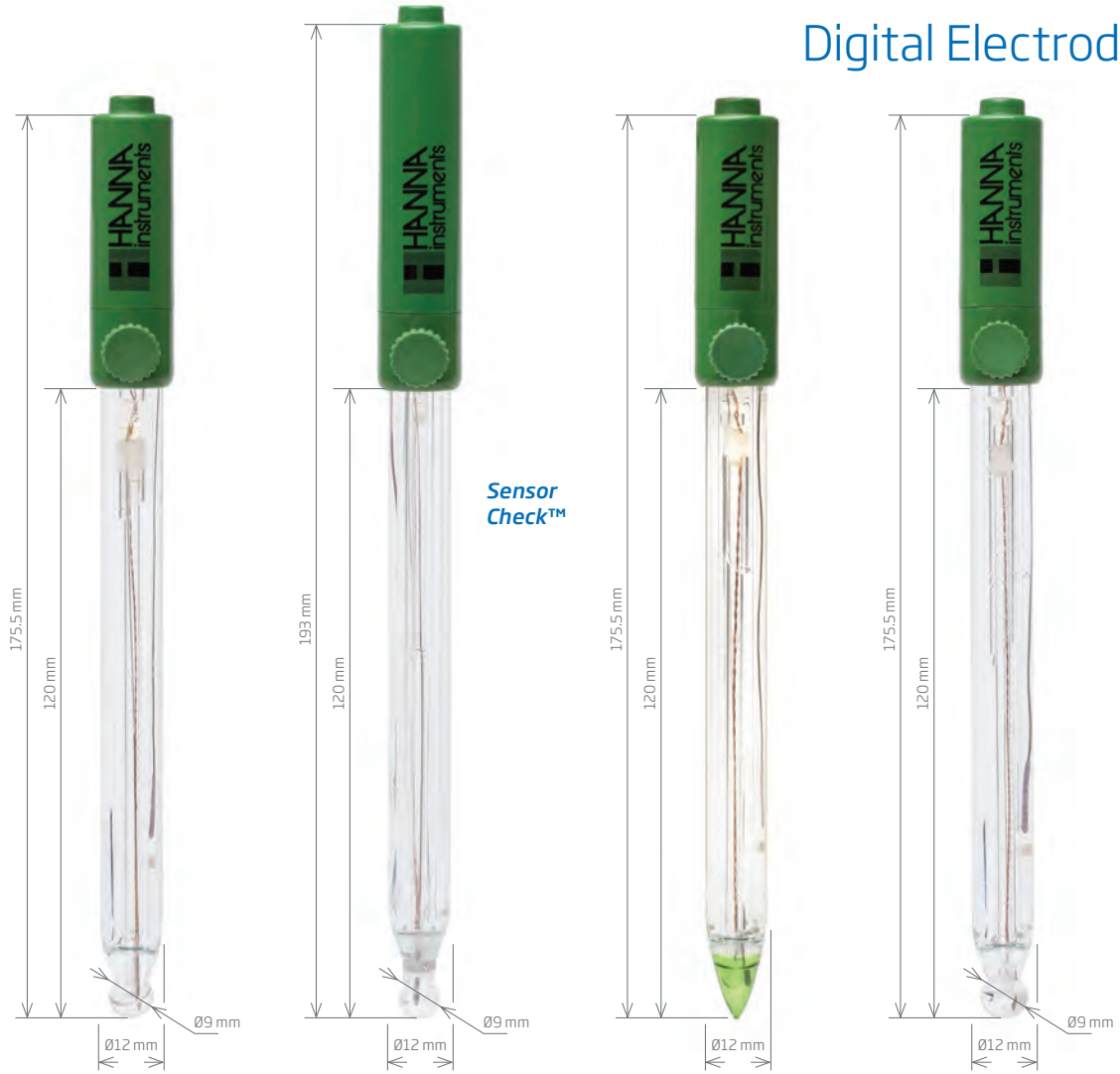
- Calibration and storage solutions should be changed regularly (i.e. monthly).
- Calibrate the meter often if a high degree of accuracy is required.
- Remember that the calibration is as only as good the buffer being used (i.e. old or contaminated buffer may not have the same value on the label).
- Single-use calibration sachets, as opposed to bottles, ensure that your buffer solution is always fresh.
- If the meter takes an unusually long time to get a stable reading, the junction may be clogged.
- Rinse the probe with purified water after each use.

Rugged pH and ORP Electrodes

Code	HI1332[ ]	HI3230B	HI36203	HI4430B
Description	pH electrode	gel-filled, combination ORP electrode w/ platinum contact	ORP probe	gel-filled, combination ORP electrode w/ gold contact
Reference	double, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl
Junction / Flow Rate	ceramic, single / 15-20 µL/h	ceramic, single	ceramic, single	ceramic, single
Electrolyte	KCl 3.5M	gel	gel	gel
Max Pressure	0.1 bar	2 bar	2 bar	2 bar
Range	pH: 0 to 13	ORP: ±2000 mV	ORP: ±2000 mV	ORP: ±2000 mV
Recommended Operating Temp.	0 to 70°C (32 to 158°F) - GP	-5 to 70°C (23 to 158°F)	-5 to 70°C (23 to 158°F)	-5 to 70°C (23 to 158°F)
Glass type	GP (general purpose)	–	–	–
Tip /Shape	spheric (dia: 7.5 mm)	platinum pin	platinum pin	gold pin
Temperature Sensor	no	no	yes	no
Amplifier	no	no	yes	no
Body Material	PEI	PEI	PEI	PEI
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	chemicals, field applications, quality control, aquariums	municipal water, quality control	field applications	oxidants, ozone
Connection	**HI1332B** BNC **HI1332P** BNC + pin* **HI1332D** DIN	**HI3230B** BNC	**HI36203** Quick Connect DIN	**HI4430B** BNC

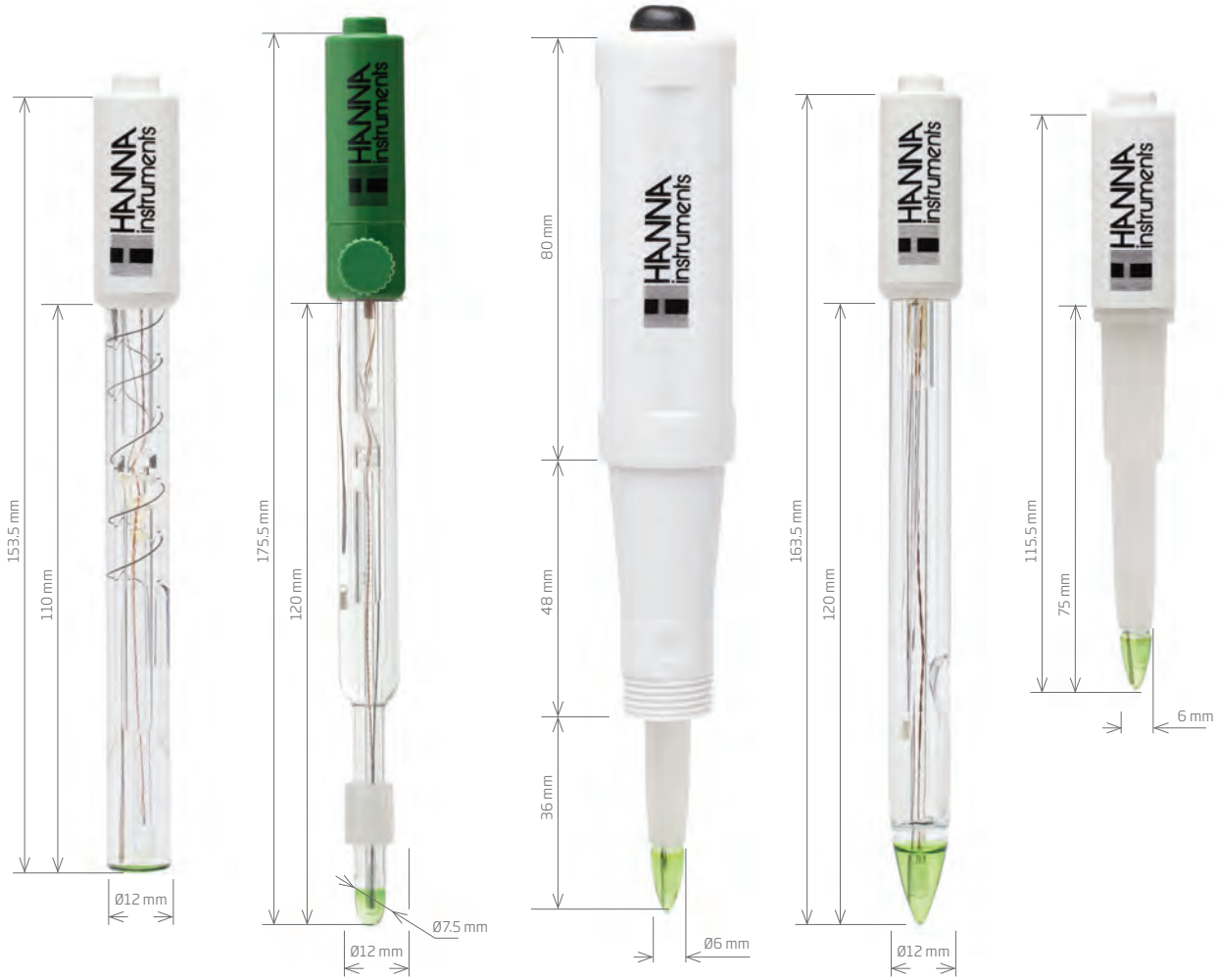
* For pH meters with CAL Check™ system

Digital Electrodes



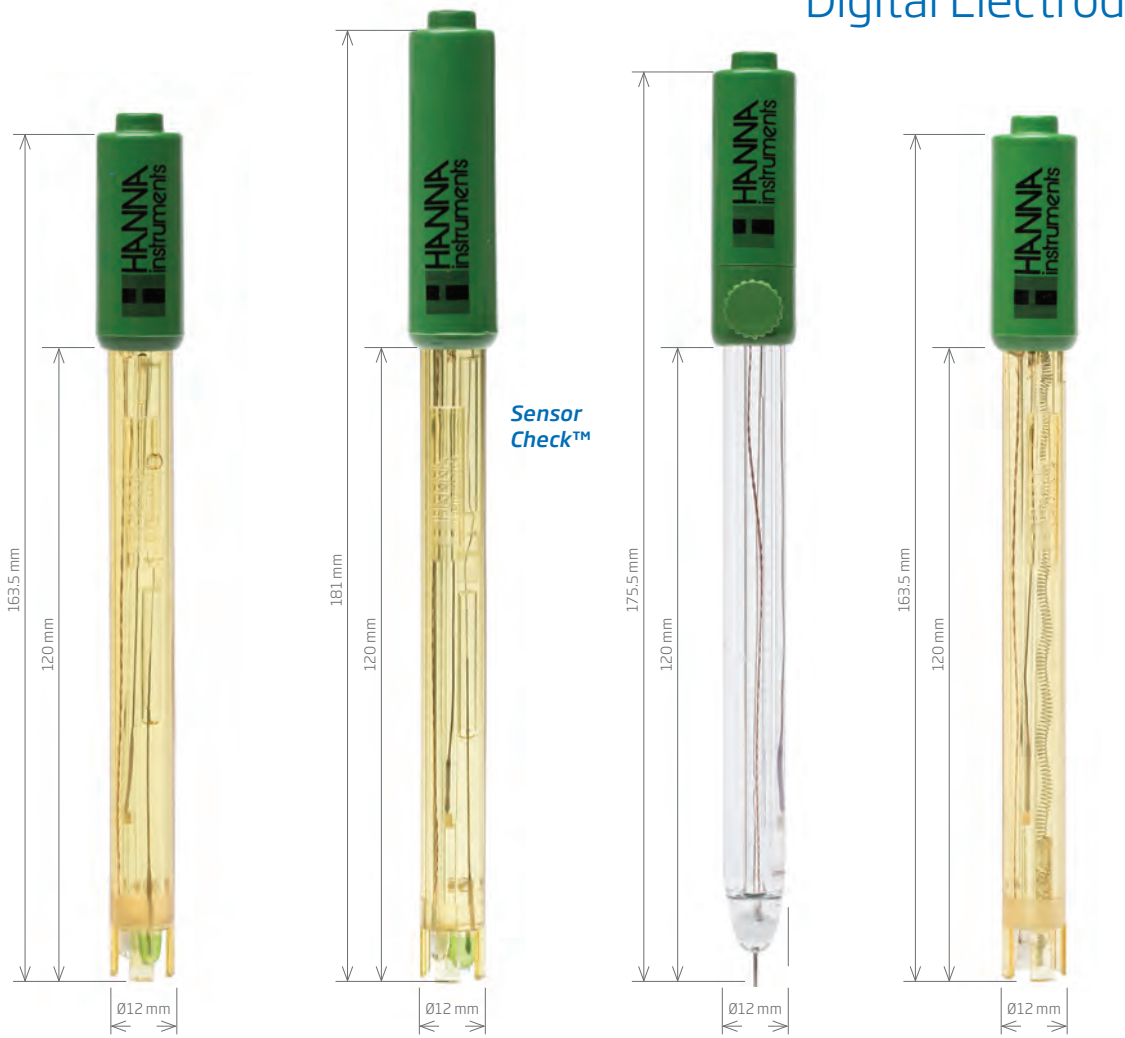
Code	HI11310	HI11311	HI10530	HI10430
Description	refillable, combination, digital pH electrode	refillable, combination, digital pH electrode w/ Sensor Check™	refillable, combination, digital pH electrode with conical tip	refillable, combination, digital pH electrode with double junction
Reference	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl
Junction	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, triple / 40-50 µL/h	ceramic, triple / 40-50 µL/h
Electrolyte	KCl 3.5M	KCl 3.5M	KCl 3.5M	KCl 3.5M
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 14	pH: 0 to 14	pH: 0 to 12	pH: 0 to 13
Recommended Operating Temp.	0 to 100°C (32 to 212°F)	0 to 100°C (32 to 212°F)	-5 to 70°C (23 to 158°F)	0 to 100°C (32 to 212°F)
Glass Type	HT (high temperature)	HT (high temperature)	LT (low temperature)	HT (high temperature)
Tip /Shape	spheric (dia: 9.5 mm)	spheric (dia: 9.5 mm)	conic (12 x 12 mm)	spheric (dia: 9.5 mm)
Temperature Sensor	yes	yes	yes	yes
Matching Pin	no	yes	no	no
Amplifier	yes	yes	yes	yes
Body Material	glass	glass	glass	glass
Cable	1 m (3.3')	1 m (3.3')	1 m (3.3')	1 m (3.3')
Recommended Use	laboratory general purpose, beer	laboratory general purpose, beer	fats and creams, high purity water, soil samples, potable water, semi-solid products, low conductivity solutions, emulsions	hydrocarbons, paints, solvents, sea water, strong acids and bases, high conductivity samples, tris buffer
Connection	**HI11310** 3.5 mm connector	**HI11311** 3.5 mm connector	**HI10530** 3.5 mm connector	**HI10430** 3.5 mm connector

Digital Electrodes



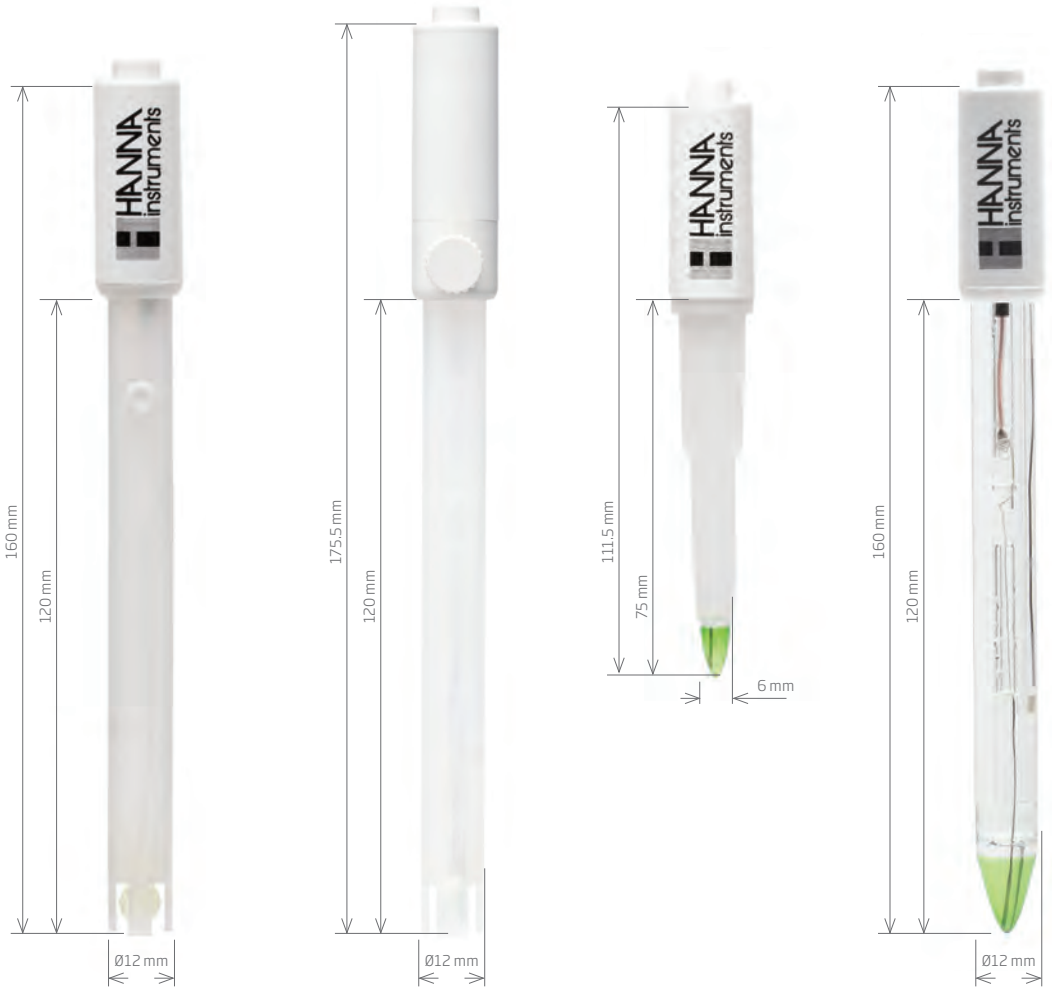
Code	HI14140	HI10480	FC2320	FC2100	FC2020
Description	digital pH electrode	refillable, digital pH electrode w/ CPS™ (clogging prevention system)	digital pH electrode	digital pH electrode	digital pH Electrode
Reference	single, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl
Junction	open	CPS™	open	open	open
Electrolyte	viscolene	KCl 3.5M	viscolene	viscolene	viscolene
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12
Recommended Operating Temp.	0 to 50°C (32 to 122°F)	-5 to 60°C (23 to 140°F)	0 to 60°C (32 to 140°F)	0 to 60°C (32 to 140°F)	0 to 60°C (32 to 140°F)
Glass Type	LT (low temperature)	LT (low temperature)	LT (low temperature)	LT (low temperature)	LT (low temperature)
Tip /Shape	flat	dome (dia: 8 mm)	conic (6 x 10 mm)	conic (12 x 12 mm)	conic (6 x 10 mm)
Temperature Sensor	yes	yes	yes	yes	yes
Matching Pin	no	no	no	no	no
Amplifier	yes	yes	yes	yes	yes
Body Material	glass	glass	PVDF	glass	PVDF
Cable	1 m (3.3')	1 m (3.3')	1 m (3.3')	1 m (3.3')	1 m (3.3')
Recommended Use	surfaces	application specific purpose, must in winemaking	application specific purpose, meat	application specific purpose, yogurt	application specific purpose, yogurt, cheese
Connection	**HI14140** 3.5 mm connector	**HI10480** 3.5 mm connector	**FC2320** 3.5 mm connector	**FC2100** 3.5 mm connector	**FC2020** 3.5 mm connector

Digital Electrodes



Code	HI12300	HI12301	HI36180	HI36200
Description	combination, digital pH electrode	combination, digital pH electrode	refillable, ORP digital probe	ORP digital probe
Reference	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	single, Ag/AgCl
Junction / Flow Rate	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, single
Electrolyte	gel	gel	KCl 3.5M + AgCl	gel
Max Pressure	2 bar	2 bar	0.1 bar	2 bar
Range	pH: 0 to 12	pH: 0 to 12	ORP: ±2000 mV	ORP: ±2000 mV
Recommended Operating Temp.	-5 to 70°C (23 to 158°F)	-5 to 70°C (23 to 158°F)	-5 to 100°C (23 to 212°F)	-5 to 70°C (23 to 158°F)
Glass Type	LT (low temperature)	LT (low temperature)	–	–
Tip /Shape	spheric (dia: 7.5 mm)	spheric (dia: 7.5 mm)	platinum pin	platinum pin
Temperature Sensor	yes	yes	yes	yes
Matching Pin	no	yes	no	no
Amplifier	yes	yes	yes	yes
Body Material	PEI	PEI	glass	PEI
Cable	1 m (3.3')	1 m (3.3')	1 m (3.3')	1 m (3.3')
Recommended Use	field applications	field applications	laboratory general purpose	field applications
Connection	**HI12300** 3.5 mm connector	**HI12301** 3.5 mm connector	**HI36180** 3.5 mm connector	**HI36200** 3.5 mm connector

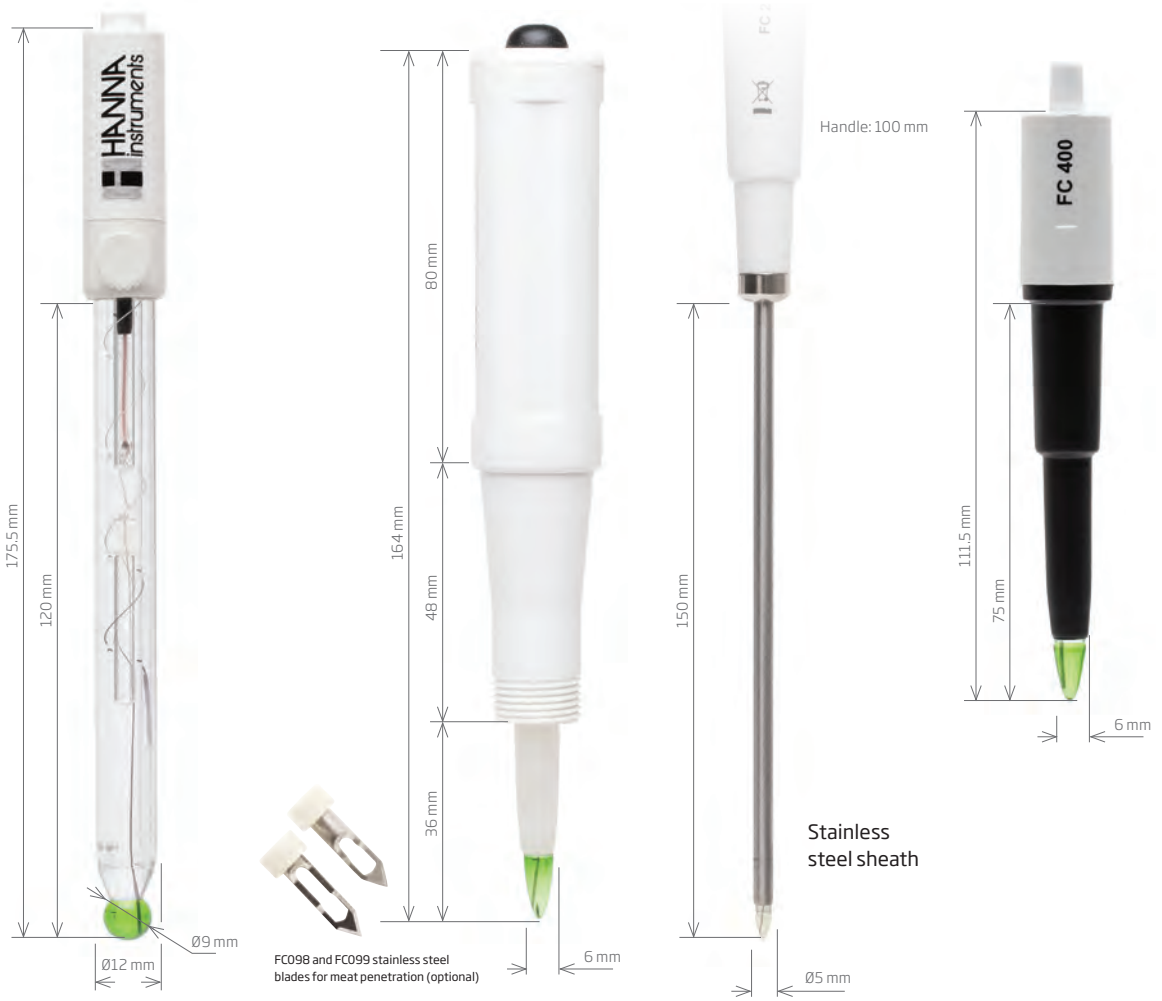
Electrodes for the Food Industry



Code	FC100B	FC1013	FC200[ ]	FC210B
Description	pH electrode	preamplified pH/ temperature probe	pH electrode	pH electrode
Reference	double, Ag/AgCl	double, Ag/AgCl	single, Ag/AgCl	double, Ag/AgCl
Junction / Flow Rate	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	open	open
Electrolyte	KCl 3.5M	KCl 3.5M	viscolene	viscolene
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 13	pH: 0 to 13	pH: 0 to 12	pH: 0 to 12
Recommended Operating Temp.	0 to 70°C (32 to 158°F)	0 to 70°C (32 to 158°F)	0 to 50°C (32 to 122°F)	0 to 60°C (32 to 140°F)
Glass Type	GP (general purpose)	GP (general purpose)	LT (low temperature)	LT (low temperature)
Tip /Shape	spheric (dia: 7.5 mm)	spheric (dia: 7.5 mm)	conic (6 x 10 mm)	conic (12 x 12 mm)
Temperature Sensor	no	yes	no	no
Amplifier	no	yes	no	no
Body Material	PVDF	PVDF	PVDF	glass
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	food industry (general use), milk	food industry (general use), milk	penetration, yogurt, cheese, semi-solid foods, fruits, ham and sausages	yogurt, creams
Connection	**FC100B** BNC	**FC1013** Quick Connect DIN*	**FC200B** BNC **FC200D** DIN	**FC210B** BNC

* Recommended for use with HI98162 and HI99162 pH meters

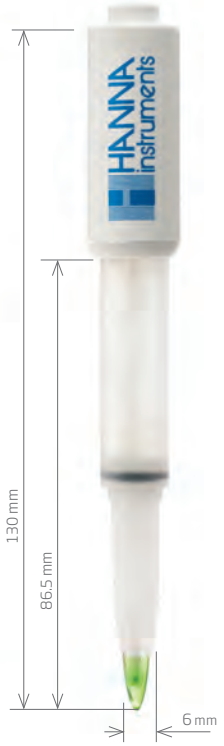
Electrodes for the Food Industry

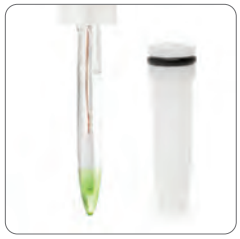


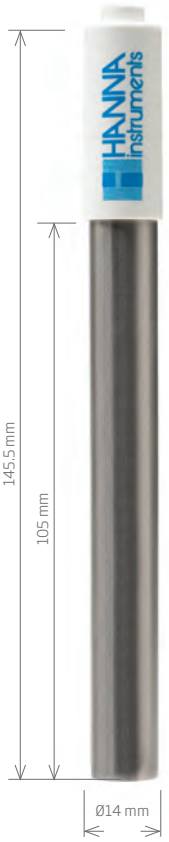
Code	FC220B	FC230B	FC240B	FC400B
Description	pH electrode	combination pH electrode with PVDF outer body	combination pH electrode with stainless steel sheath	pH electrode
Reference	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl	double, Ag/AgCl
Junction / Flow Rate	ceramic, triple / 40-50 µL/h	open	open	open
Electrolyte	KCl 3.5M + AgCl	viscolene	gel	viscolene
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 12	pH: 0 to 12	pH: 0 to 13	pH: 0 to 12
Recommended Operating Temp.	-5 to 70°C (23 to 158°F)	0 to 50°C (32 to 122°F)	0 to 50°C (32 to 122°F)	0 to 60°C (32 to 140°F)
Glass Type	LT (low temperature)	LT (low temperature)	GP (general purpose)	LT (low temperature)
Tip /Shape	spheric (dia: 9.5 mm)	conic (6 x 10 mm)	conic (3 x 5 mm)	conic (6 x 10 mm)
Temperature Sensor	no	no	no	no
Amplifier	no	no	no	no
Body Material	glass	PVDF	titanium	PVDF
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	creams, fruit juices, sauces	meat, semi frozen products	penetration, cheese, quality control	penetration, meat
Connection	**FC220B** BNC	**FC230B** BNC	**FC240B** BNC	**FC400B** BNC

Electrodes for the Food Industry

CPS™ (Clogging Prevention System)







Code	HI1048[ ] • FC10483	FC911	FC2023	FC2053	FC2143
Description	pH electrode with CPS™ (Clogging Prevention System)	pH electrode	pH electrode	pH electrode	pH electrode
Reference	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	double, Ag/AgCl	single, Ag/AgCl
Junction / Flow Rate	CPS™	ceramic, single / 15-20 µL/H	open	open	cloth
Electrolyte	KCl 3.5M	KCl 3.5M	viscolene	gel	gel
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar	3 bar
Range	pH: 0 to 12	pH: 0 to 13	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12
Recommended Operating Temp.	-5 to 60°C (23 to 140°F)	0 to 70°C (32 to 158°F)	0 to 60°C (32 to 140°F)	0 to 60°C (32 to 140°F)	0 to 80°C (32 to 176°F)
Glass Type	LT (low temperature)	GP (general purpose)	LT (low temperature)	LT (low temperature)	LT (low temperature)
Tip /Shape	dome (dia: 8 mm)	spheric (dia: 7.5 mm)	conic (6 x 10 mm)	conic (6 x 10 mm)	flat
Temperature Sensor	DIN model only	no	yes	yes	yes
Amplifier	DIN model only	yes	yes	yes	yes
Body Material	glass	PVDF	PVDF	PVDF	titanium with HT glass sensor
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	7-pole; 1 m (3.3')	7-pole; 1 m (3.3')	7-pole; 1 m (3.3')
Recommended Use	must in winemaking	creams, fruit juices, sauces, high humidity	yogurt, cheese, meat, semi-solid foods, fruits, ham and sausages	yogurt, cheese, meat, semi-solid foods, fruits, ham and sausages	beer
Connection	**HI1048B** BNC **HI1048B/50** BNC (.4 m (1.3') cable) **HI1048P** BNC + pin* **FC10483** Quick Connect DIN**	**FC911B** BNC	**FC2023** Quick Connect DIN *	**FC2053** Quick Connect DIN *	**FC2143** Quick Connect DIN *

* For pH meters with CAL Check™ system
** Recommended for use with HI99111 pH meter

* Recommended for use with HI98161 and HI99161 pH meters

* Recommended for use with HI98161 pH meter

* Recommended for use with HI98151 pH meter

Electrodes for the Food Industry

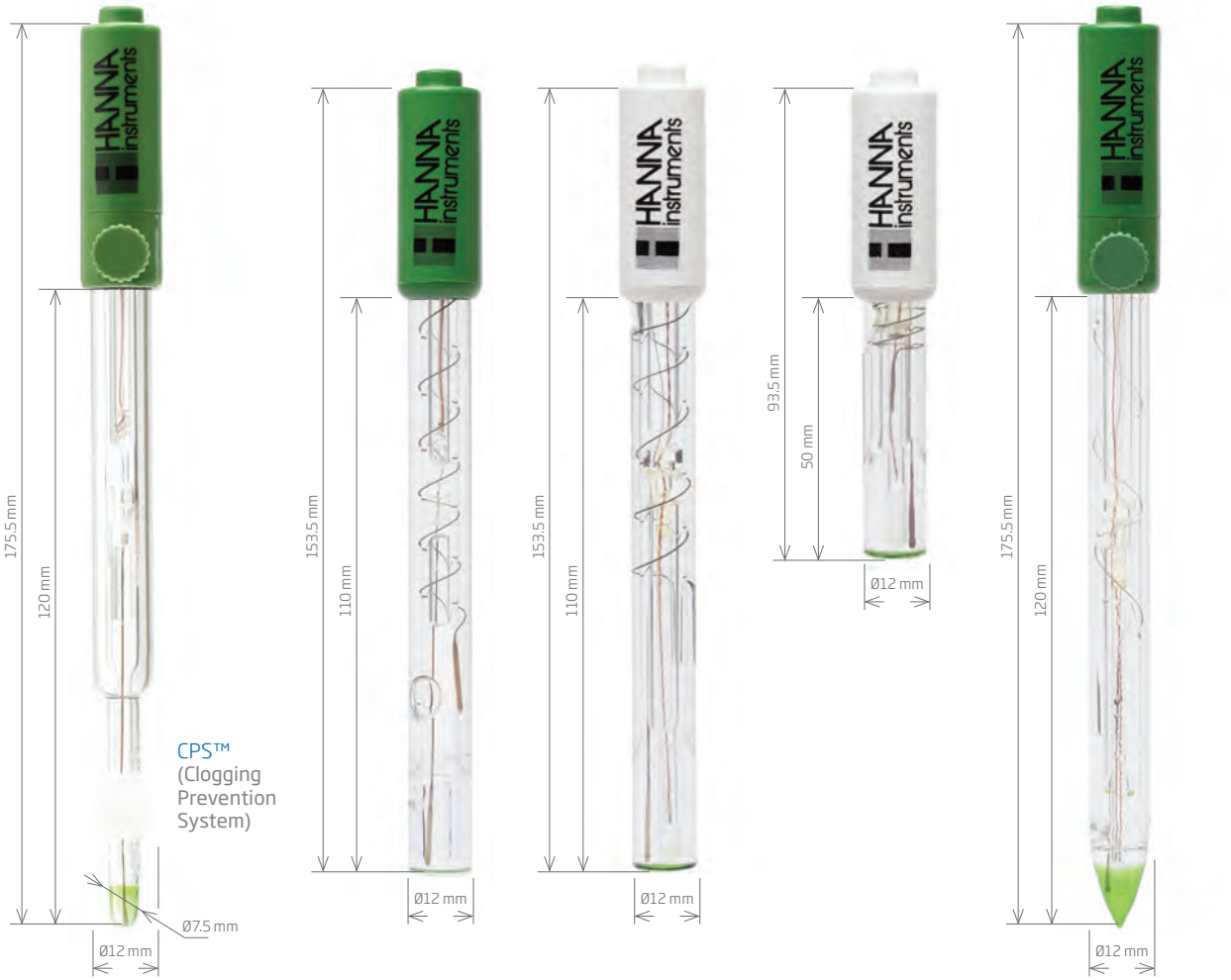
Code	FC2323	HI3148B	FC2133	FC2423	FC2423-1
Description	pH electrode	ORP electrode	pre-amplified pH / temperature probe	pre-amplified pH / temperature probe	pre-amplified pH / temperature probe
Reference	single, Ag/AgCl	double, Ag/AgCl	double	single	single
Junction	open	CPS™	open	open	open
Electrolyte	viscolene	KCl 3.5M	viscolene	viscolene	viscolene
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 12	ORP: ±2000 mV	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12
Recommended Operating Temp.	0 to 50°C (32 to 122°F) - LT	-5 to 60°C (23 to 140°F)	0 to 60°C (32 to 140°F)	0 to 50°C (32 to 122°F)	0 to 50°C (32 to 122°F)
Glass type	LT (low temperature)	–	LT (low temperature)	LT (low temperature)	LT (low temperature)
Tip /Shape	conic (6 x 10 mm)	platinum ring	conic	conic (6 x8 mm)	conic
Temperature Sensor	yes	no	yes	yes	yes
Amplifier	yes	no	yes	yes	yes
Body Material	PVDF	glass	glass	titanium	titanium
Cable	7-pole; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')
Recommended Use	meat	must in winemaking	yogurt	penetration, cheese	penetration, cheese
Connection	**FC2323** Quick Connect DIN*	**HI3148B** BNC **HI3148B/50** BNC (.4 m (1.3') cable)	**FC2133** Quick Connect DIN*	**FC2423** Quick Connect DIN*	**FC2423** Quick Connect DIN*

* Recommended for use with HI98163 and HI99163 pH meters

* Recommended for use with HI98164 and HI99164 pH meter

* Recommended for use with HI98165 and HI99165 pH meter

Electrodes for Specific Analysis

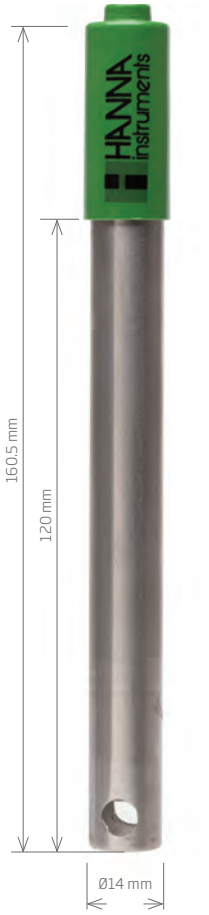


Code	HI1049B	HI1413B	HI14143	HI14143/50	HI12923
Description	pH electrode with CPS™ (Clogging Prevention System)	pH electrode	pH electrode	pH electrode	pH electrode
Reference	double, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl
Junction	CPS™	open	open	open	ceramic, triple / 40-50 µL/h
Electrolyte	KCl 3.5M	viscolene	viscolene	viscolene	KCl 3.5M + AgCl
Max Pressure	0.1 bar	0.1 bar	0.1 bar	0.1 bar	0.1 bar
Range	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12	pH: 0 to 12
Recommended Operating Temp.	0 to 60°C (32 to 140°F)	0 to 50°C (32 to 122°F)	0 to 50°C (32 to 122°F)	0 to 50°C (32 to 122°F)	-5 to 70°C (23 to 158°F)
Glass Type	LT (low temperature)	LT (low temperature)	LT (low temperature)	LT (low temperature)	LT (low temperature)
Tip /Shape	dome (dia: 8 mm)	flat	flat	flat	conic (12 x 12 mm)
Temperature Sensor	no	no	yes	yes	yes
Amplifier	no	no	yes	yes	yes
Body Material	glass	glass	glass	glass	glass
Cable	coaxial; 1 m (3.3')	coaxial; 1 m (3.3')	7-pole; 1 m (3.3')	7-pole; 1 m (3.3')	7-pole; 1 m (3.3')
Recommended Use	non-aqueous titrations	surface, skin, leather, paper, emulsions	surface, leather, paper, emulsions	skin, scalp	direct soil pH measurement, soil solution
Connection	**HI1049B** BNC	**HI1413B** BNC	**HI14143** Quick Connect DIN*	**HI14143/50** Quick Connect DIN*	**HI12923** Quick Connect DIN*
			* Recommended for use with HI99171 pH meter	* Recommended for use with HI99181 pH meter	* Recommended for use with HI99121 pH meter

Electrodes for Specific Analysis

Code	HI12943	FC2153	HI12963	HI12973
Description	pH electrode	pH electrode	pH electrode	pH/ORP electrode
Reference	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl	single, Ag/AgCl
Junction	ceramic, triple / 40-50 µL/h	ceramic, triple	cloth	cloth
Electrolyte	KCl 3.5M + AgCl	KCl 3.5M + AgCl	gel	gel
Max Pressure	0.1 bar	0.1 bar	3 bar	3 bar
Range	pH: 0 to 12	pH: 0 to 12	pH: 0 to 13	pH: 0 to 13; ORP
Recommended Operating Temp.	-5 to 70°C (23 to 158°F)	-5 to 70°C (23 to 158°F)	0 to 70°C (32 to 158°F)	0 to 70°C (32 to 158°F)
Glass Type	LT (low temperature)	LT (low temperature)	GP (general purpose)	GP (general purpose)
Tip /Shape	conic (12 x 12 mm)	spheric (dia: 9.5 mm)	spheric (dia: 5 mm)	pH: conic (3 mm); ORP: platinum sensor
Temperature Sensor	yes	yes	yes	yes
Amplifier	yes	yes	yes	yes
Body Material	glass	glass	titanium	titanium
Cable	7-pole; 1 m (3.3')	coaxial; 1 m (3.3')	7-pole; 1 m (3.3')	7-pole; 1 m (3.3')
Recommended Use	direct soil, soilless media, soil solution	drinking water	wastewater	wastewater, municipal water, water treatment, swimming pools
Connection	**HI12943** Quick Connect DIN*	**FC2153** DIN*	**HI12963** Quick Connect DIN*	**HI12973** Quick Connect DIN*
	* Only for use with HI9814 GroLine® multiparameter meter	* Recommended for use with HI99192 pH meter	* Recommended for use with HI98190 and HI991001 pH meter	* Recommended for use with HI991003 pH meter

Electrodes for Specific Analysis



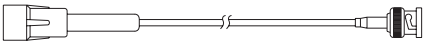
Code	HI629113	HI72911[ ]
Description	pH electrode	pH electrode
Reference	double, Ag/AgCl	double, Ag/AgCl
Junction	PTFE	PTFE
Electrolyte	polymer	polymer
Max Pressure	3 bar	3 bar
Range	pH: 0 to 13	pH: 0 to 13
Recommended Operating Temp.	0 to 80°C (32 to 176°F)	0 to 80°C (32 to 176°F)
Glass Type	GP (general purpose)	GP (general purpose)
Tip /Shape	flat	flat
Temperature Sensor	yes	yes
Amplifier	yes	yes
Body Material	titanium body working as matching pin	
Cable	7-pole; 1 m (3.3')	7-pole; 1 m (3.3')
Recommended Use	plating baths	cooling towers, boilers
Connection	**HI629113** Quick Connect DIN*	**HI729113** Quick Connect DIN** **HI72911B** BNC + phono†

* Recommended for use with HI99131 pH meter

** Recommended for use with HI99141 pH meter
† Recommended for use with HI98191 pH meter

Electrode Extension Cables

Screw Type to BNC Cables / Connectors

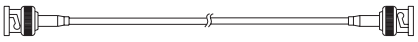


Description

3.0 mm (0.12") cable with screw type and BNC connectors

Part #	Cable Length
HI7855/1	1 m (3.3')
HI7855/3	3 m (9.9')
HI7855/5	5 m (16.5')
HI7855/10	10 m (33')
HI7855/15	15 m (49.5')

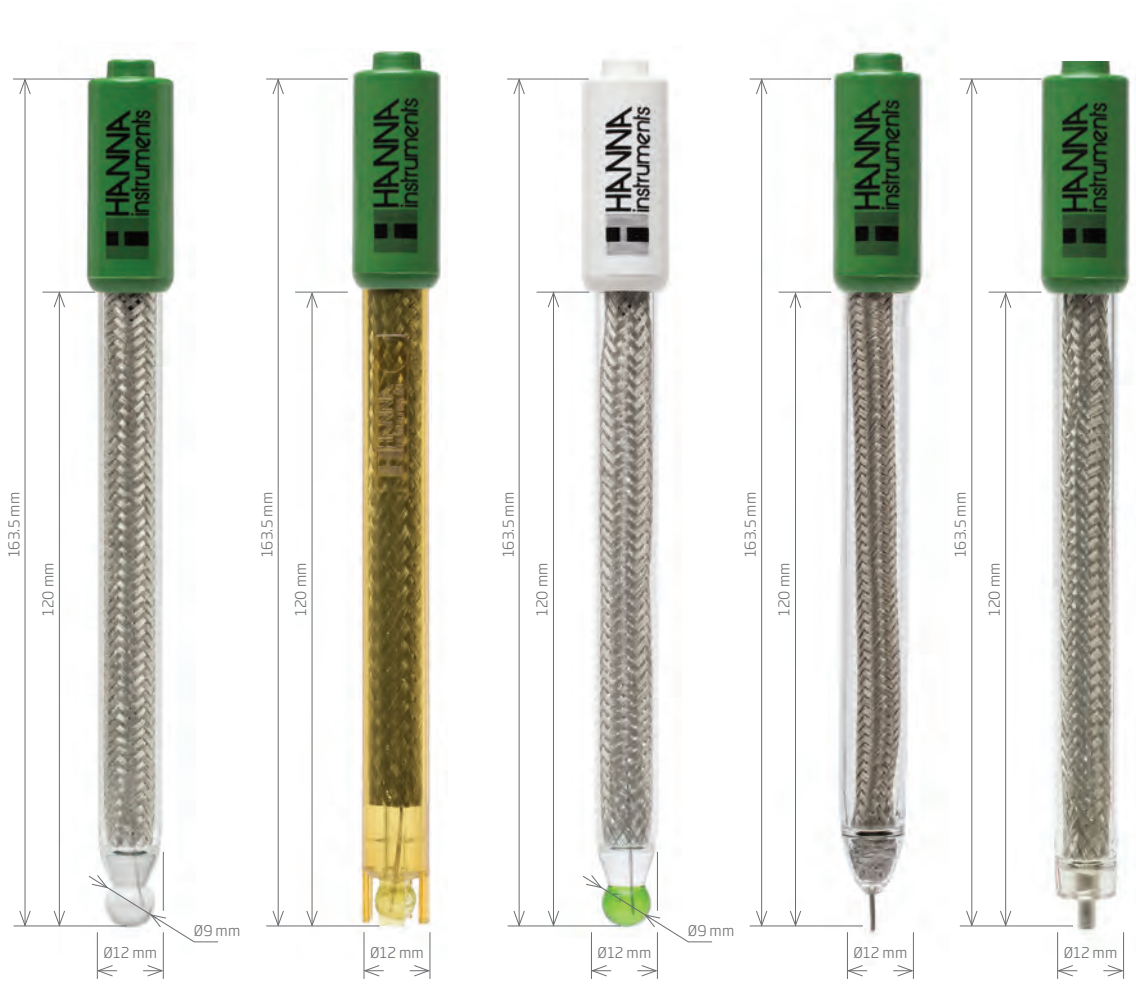
BNC to BNC Cables / Connectors



Description

3.0 mm (0.12") cable with BNC connectors

Part #	Cable Length
HI7858/1	1 m (3.3')
HI7858/5	5 m (16.5')
HI7858/10	10 m (33')



Code	HI2111B	HI2112B	FC260B	HI3133B	HI5110B
Description	pH half-cell	pH half-cell	pH half-cell	ORP half-cell	ORP half-cell
Half Cell	–	–	–	platinum	Ag
Range	pH: 0 to 14	pH: 0 to 13	pH: 0 to 12	mV	mV
Recommended Operating Temp.	0 to 100°C (32 to 212°F)	0 to 70°C (32 to 158°F)	-5 to 80°C (23 to 176°F)	-5 to 100°C (23 to 212°F)	0 to 70°C (32 to 158°F)
Glass Type	HT (high temperature)	GP (general purpose)	LT (low temperature)		
Tip /Shape	spheric (dia: 9.5 mm)	spheric (dia: 7.5 mm)	spheric (dia: 9.5 mm)	platinum pin	cylindric (dia: 3 mm)
Body Material	glass	PEI	glass	glass	glass
Cable	coaxial	coaxial	coaxial	coaxial	coaxial
Recommended Use	general purpose, strong alkaline solutions	general purpose	milk	general purpose, potentiometric titration	argentometric titration
Connection	**HI2111B** BNC	**HI2112B** BNC	**FC260B** BNC	**HI3133B** BNC	**HI5110B** BNC

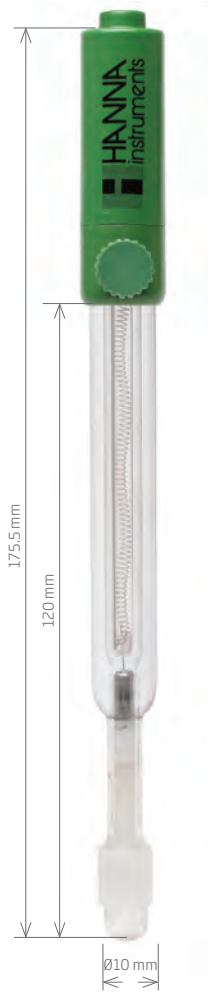
Reference Electrodes

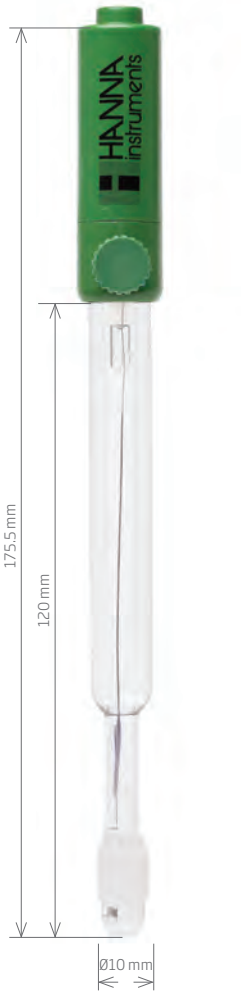
Code	HI5412	HI5311	HI5314	HI5414
Description	reference electrode	reference electrode	reference electrode	reference electrode
Reference	single, Hg/Hg_2Cl_2	double, Ag/AgCl	double, Ag/AgCl	single, Hg/Hg_2Cl_2
Junction / Flow Rate	ceramic, single / 15-20 µL/h	ceramic, single / 15-20 µL/h	ceramic, double	ceramic, double
Electrolyte	KCl 3.5M	KCl 3.5M	KCl 3.5M	KCl 3.5M
Max Pressure	0.1 bar	0.1 bar	3 bar with back pressure	3 bar with back pressure
Recommended Operating Temp.	-5 to 60°C (23 to 140°F)	-5 to 100°C (23 to 212°F)	-5 to 100°C (23 to 212°F)	-5 to 60°C (23 to 140°F)
Body Material	glass	glass	glass	glass
Cable	1 m (3.3')	1 m (3.3')	1 m (3.3')	1 m (3.3')
Recommended Use	general purpose, titrations	general purpose, titrations	measurements with remote filling	measurements with remote filling
Connection	**HI5412** 4 mm banana	**HI5311** 4 mm banana	**HI5314** 4 mm banana	**HI5414** 4 mm banana

High pressure or high concentration of contaminants

Because of the special electrode recharge system of the HI5314 and HI5414, it is possible to connect an outside container. This will increase the amount of electrolyte of the reference half cell and thus, the pressure inside the electrode. By so doing, the junction has the ability to work in high pressure environments without the danger of implosion.

Reference Electrodes





Code	HI5413	HI5312	HI5313
Description	reference electrode	reference electrode	reference electrode
Reference	single, Hg/Hg_2Cl_2	double, Ag/AgCl	single, Ag/AgCl
Junction / Flow Rate	PE sleeve	PE sleeve	ceramic
Electrolyte	KCl 3.5M	KCl 3.5M	gel (KCl 1M + AgCl)
Max Pressure	0.1 bar	0.1 bar	0.1 bar
Recommended Operating Temp.	-5 to 60°C (23 to 140°F)	0 to 60°C (32 to 140°F)	-5 to 60°C (23 to 140°F)
Body Material	glass	glass	PEI
Cable	1 m (3.3')	1 m (3.3')	1 m (3.3')
Recommended Use	samples with suspended solids	titrations, samples with suspended solids	titrations, samples with suspended solids
Connection	**HI5413** 4 mm banana	**HI5312** 4 mm banana	**HI5313** 4 mm banana